PRITCHARD, A.

A GENERAL HISTORY OF ANIMALCULES.

ILLUSTRATED BY FIVE HUNDRED ENGRAVED DRAWINGS.

BEING

PART I. OF "A HISTORY OF INFUSORIA, LIVING AND FOSSIL."

BY

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PREFACE.

The following pages—part of *A History of Infusoria*—are offered to the public in the hope that they, together with the engravings, may extend and advance the study of this subject, by presenting a general outline of the History of Animalcules to those persons who do not feel disposed to enter into the minutiæ contained in the body of the work from which they are taken.

In no branch of Natural History are drawings of the subjects more necessary. With this impression, the Author not only gave a greater number than is contained in any previous volume, but devoted much time and expense in the introduction of accurate details. This augmented the cost: many persons have been thereby prevented from obtaining that work. In the present tract this is obviated, the price being reduced to the utmost.

The kind patronage of those who appreciate works of this class is therefore respectfully solicited in its favour.

162, Fleet Street,
London, January, 1843.

Mr. PRITCHARD, having been for several years engaged as Patent Agent, offers his assistance to Patentees, Inventors, and others, in the various branches connected with the Patent Business, especially *either* of the following:—

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CONTENTS.

ERRATA.

Page.	Line.	*For—*	*Read—*
1 ...	11 ...	diminitive	diminutive.
15 ...	18 ...	filaform	filiform.
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PART I.

GENERAL HISTORY

OF

INFUSORIAL ANIMALCULES.

Among the arguments dedueible from the natural world, in support of the existence and superintending Providenee of an Almighty Intelligence, none can earry a stronger eonviction home to a reasoning and philosophie mind, than those whieh are drawn from that portion of it which falls under eonsideration in the present treatise. Interspersed throughout this world of nature, designed and formed by a graeious and All-wise Creator—if, with no other intention, still, with that of yielding evidence indisputable of His own Omnipotence—exists a world within a world, of beings so diminitive, as to have provoked man's utmost ingenuity to bring them within the range of his pereeptive powers.

"In the clearest waters, and also in the troubled, strongly acid, and salt fluids of the various zones of the earth; in springs, rivers, lakes, and seas; in the internal moisture of living plants and animal bodies, and, probably, at times, carried about in the vapour and dust of the whole atmosphere of the earth, exists a world, by the common senses of mankind unperceived, of very minute living beings, which have been called, for the last seventy years, INFUSORIA. In the ordinary pursuits of life, this mysterious and infinite kingdom of living creatures is passed by without our knowledge of, or interest in, its wonders. But, to the quiet observer, how astonishing do these become, when he brings to his aid those optical powers by which his faculty of vision is so much strengthened. In every drop of dirty stagnant water, we are generally, if not always, able to perceive, by means of the microscope, moving bodies, of from 1-1150th to 1-25,000th of an inch in diameter; and which often live packed together so closely, that the space between each individual scarcely equals that of their diameter."

The wisdom and goodness of Providence have endowed these living creatures with all that can be needed for their happy existence. A reference to the drawings, generally, will afford some idea of their beautiful and varied forms. What, for instance, can be more admirable in structure than the Infusoria of the family Volvocina? (See *Plate* I. *figs*. 34 to 57.) In what class of animals are its members so curiously and so symetrically associated together? In the Volvocina, innumerable beings are colonized within a simple, delicate, crystal-like shell, whose form, sometimes spherical, at others quadrangular, presents us with

examples of perfect harmony and proportion. Who can behold these hollow living globes, revolving and disporting themselves in their native element, with as much liberty and pleasure as the mightiest monster of the deep:—and, to carry our views a step further, to speak in detail of series of globes, one within another, alike inhabited, and their occupants alike participating in the same enjoyment —who can behold such evidences of creative wisdom, and not exclaim with the Psalmist, "How wonderful are thy works, O Lord, *sought out* of all them that have *pleasure therein!*"

Again, take an example from the *most minute* of living beings to which our knowledge at present extends, such as the Monas crepusculum (see Part II.), and compute the number which could occupy the bulk of a single grain of mustard seed, the diameter of which does not exceed the tenth of an inch: it is hardly conceivable that within that narrow space *eight millions* of active living creatures can exist, all richly endowed with the organs and faculties (as hereinafter fully described) of animal life! Such, however, is the astonishing fact. Again, to take an example from those families of Infusoria, who posses the power of *changing their forms* at pleasure, and yet confine it to the drawings of the first plate (although the second would furnish *protean* phenomena of a more extraordinary character), take the figures of the family Astasiæa (*groups* 68 to 82), and you have creatures capable of assuming all the various forms there depicted, in the short interval of a few seconds, and that under the observer's eye. In the beautiful little creatures of the genus Euglena, you may also perceive a distinct *visual organ*, by which they can

steer their course with unerring rectitude. Many of the Infusoria do not possess this organ. But, mark the all-wise dispensation of Providence in this respect!—those which have it live, for the most part, near the surface of the water, whilst those which have it not, as the Bacillaria, locate near the bottom. This circumstanee in their economy has not hitherto been noticed.

Lastly,—still restricting our observations to the drawings of the first plate, look at the graceful forms of the small family Closterina (*fig.* 63 to *group* 67), which have long rivetted the attention of the most eminent naturalists of modern times, and which have hitherto defied all their powers of investigation, aided by all the refined and searching means which human ingenuity can supply, to determine whether they are animals or plants! No characteristic, at present known, has been found sufficient to satisfy both the zoologist and botanist.

In short, there is not one species, out of the seven hundred and thirty-two described in the seeond part of this work, but offers ample scope for the exercise of our deepest reflection, at the same time that it affords an admirable proof of the adaptation and design of Creative Wisdom.

For the eonvenience of reference, it is proposed to divide this part into seetions; and, although the subjects treated of may not, as respccts some few of them, have reeeived all that careful investigation whieh they deserve, yet it is presumed that sufficient has been done to lcad the minds of the more curious inquirer to a further research. Previous to which, I present the reader with Dr. Ehrenberg's summary of the subject:—

1. All the Infusoria are organized, and the greater part of them (probably all) are *highly* organized bodies.

2. The Infusoria constitute two very natural classes of animals, according to their structure, which classes admit of subdivision, upon the same principle.

3. The existence of the Infusoria in the four quarters of the globe, and the sea, is proved; as also that of individuals of the same species in the most opposite ends of the world.

4. The geographical distribution of the Infusoria upon the earth follows the laws observed regulating that of other natural bodies.

5. Most of the Infusoria are invisible to the naked eye; many are visible as moving points; and the size of the body does not exceed, in any case, the 1-12th of an inch.

6. The minute invisible Infusoria, in consequence of their immense and swarming numbers, colour large tracts of water with very remarkable hues.

7. They give rise to one kind of phosphorescence of the sea, though in themselves invisible.

8. They compose (though singly invisible) a sort of mould, through living in dense and crowded masses.

9. In a cubic inch of this mould, more than 41,000 millions of single animals exist, and constitute, most likely, the chief proportion of living bodies upon the face of the earth.

10. The Infusoria are the most reproductive of organised bodies.

11. From one of the known propagative modes of the Infusoria—that is, of self-division—a continual destruction, beyond all idea, of the individual, and a similar inter-

minable preservation and extension of it, in air and water, ensues, which, poetically, borders upon eternal life and growth.

12. The copulation of gemmæ, which perhaps includes the hitherto unsolved poly-embryonate riddle of the seeds of all plants and vegetable formations, is solved in the family Closterina.

13. The Infusoria, in consequence of their siliceous shells, form indestructible earths, stone, and rocky masses.

14. With lime and soda we can prepare glass, and swimming bricks, out of invisible animalcules; use them as flints; probably prepare iron from them; and use the *mountain meal,* composed of them, as food in hunger.

15. The invisible Infusoria are sometimes hurtful, by causing the death of fish in ponds, deterioration of clear water, and boggy smells; but not, as has been supposed, in giving rise to malaria, plague, and other maladies.

16. The Infusoria appear to be (as far as is yet known) sleepless.

17. The Infusoria partly decompose (zerfliessen) by egg laying, and through that change passively, and manifold their form.

18. The Infusoria form invisible intestinal worms in many animals and in man, even if the Spermatozoa are excluded from amongst them.

19. The invisible Infusoria have also *lice* and *intestinal worms* themselves.

20. The Infusoria possess a comparatively long life.

21. As the pollen of the Pine falls yearly from the clouds, in the form of *sulphur-rain,* so do the much smaller

animalcules appear (from being passively elevated with the watery vapour) floating in a live state in the atmosphere, and sometimes, perhaps, mixed with the dust.

22. In general, the Infusoria maintain themselves pretty uniformly against all external influenee, as do larger organized bodies. It is true that they sometimes eonsume strong poisons without *immediate injury*, but not without an after effeet.

23. The weight of the invisible Infusoria, light as it is, is yet ealculable, and the most gentle eurrent of air or draught can play with their bodies as with the vapour of water.

24. The evident and great quickness of the motion of Infusoria, is redueible as follows: Hydatina senta, 1-12th of an ineh in four seconds; Monas punctum, 1-12th in forty-eight seeonds; Navieula graeilis, 1-12th in six minutes twenty-four seconds.

25. Linneus said, *omnis calx e vermibus*:—either to maintain or deny *omnis silex omne ferrume vermibus*, would be, at the present moment, unjust.

26. The direct observations as yet known upon the theory of *generatio primitiva* are wanting in neeessary strictness. Those observers, who profess to have seen the sudden origin of the minutest Infusoria from elementary substanees, have quite overlooked the eompound strueture of these organic bodies.

27.

28. The power of infusorial organization is instinetively shown by the strong ehewing apparatus, with teeth, whieh they possess, and their evincement, likewise, of a eomplete mental aetivity.

29. The study of the Infusoria has led to a more distinct and conclusive notion of animal organization generally, and the limits which circumscribe the animal form; from which all plants and minerals, that want the animal organic system, are strongly and distinctly separated.

30. Finally,—it results from these inquiries, that experience shows an unfathomableness of organic creations, when attention is directed to the smallest space, as it does of stars, when reverting to the most immense.

Section I.—*Localities and Appearance of Infusoria in Masses.*

In investigating most branches of practical science, especially those relating to Natural History, the subjects to which our observations are to be directed are generally difficult of attainment, and the inquiry cannot be prosecuted without considerable inconvenience. This, however, is not the case with respect to the *Infusorial Animalcules.* We can examine them in our chamber, at any leisure moment we like, and at any time or season; and we can procure them, at least the ordinary kinds, such as the Paramecium, Kolpoda, &c., with the utmost facility, —for they abound in most waters wherein the stalks of flowers have been a few days steeped—whilst many of the more beautiful kinds, such as the Volvocina, Astasiæa, Hydatinæa, &c., are to be found in pools of clear standing water.

Many remarkable species, and some of the most elegant

I have ever examined, have been taken in meadow-trenches, in the slowly running water, after a summer shower, and especially about the period that the first crop of hay was mown. Among healthy water plants, such as the Chara, Cerotophyllum, Confervæ, Lemna, &c., the various kinds of Vorticellina and Rotatorial animalcules may be sought for with success. The stems of aquatic plants, particularly those of the description just mentioned, have often the appearance, to the naked eye, of being encased with mouldiness or *mucor,* which, on being examined under the microscope, proves to be an extensive colony of arborescent animalcules. Whenever this appearance is of a bluish-milky hue, the species will mostly be those of the Vorticella or Epistylis. (See the *Engravings.*) If you observe little dark bristle-like bodies standing out among the stems, you may expect them to be the Melicerta; and the little yellow gelatinous balls upon the Ceratophillum are, probably, the Megalatrocha. In clear shallow pools, the Volvox globator (*fig.* 55) may be met with in vast numbers in the spring of the year; and, when these are found amongst Lemna, by examining them under a deep magnifying power, you may often discover, within their hollow spheres, the Notomata parasita, like so many white specks. The dust-like stratum we frequently notice on the surface of stagnant ponds, is often composed almost entirely of species of the most beautiful colours, such as the Euglena, Chlorogonium, Pandorina, Gonium, and Bursaria. The thin shining film, which sometimes covers plants in pools of water, assuming the varied hues of red, brown, yellow, green, and blue, is made up also of infusorial animalcules. For example—those objects, which under water appear to

be coated with a thick green matter, abound with the different species of the Euastra and Closterium, the Arthrodesmus quadricaudatus and pectinatus, the Stentor polymorphus, and Vorticella chlorostigma; and those objects which have a bright orange-coloured coating, derive it from the presence of the Stentor aureus.

The abode of animalcules is not, however, confined to the clear fresh water of lakes, rivers, pools, springs, and trenches, but extends even to the briny ocean, to strong acids, tannin, and the fluids contained in the animal and vegetable creation. In moist earth, the species of Bacillaria and other shelled animalcules may also be found; and even the very air we breathe may teem with them and their germs, whilst the gentlest breeze will be sufficient to waft them in myriads over the distant waters, and to transport these living atoms throughout the face of Nature. So that, in short, whether we descend into the deepest mines, where darkness ever reigns, or climb the loftiest mountains, whose summits glow with almost perpetual sunshine, there shall we find them located alike.

Although the colouring of water is sometimes derived from the oxides of iron and other mineral or earthy substances over which it flows, or from the Oscillatoria and other minute algæ which it contains, an intensity of colouring will also be given it by the presence of infusorial animalcules. Thus the Astasia imparts a blood-red colour, as also the Euglena ruber; the Gallionella, Navicula, and Gomphonema, impart an ochreous hue. Blue proceeds from the Stentor ceruleus. Masses of water assume an intense green from Monas bicolor, Uvella bodo, Glenomorum tingens, Phacelomonas pulvisculus,

Cryptomonas glauca, Cryptoglena conica, Pandorina morum, Gonium pectorale, Chlamidomonas pulv., Volvox glob., Astasia and Euglena sang., when young; Euglena viridis, Chlorogonium enchylis, and Ophrydium versatile: yellow from the Astasia flavicans; a milky tint from the Polytoma uvella, and Ophryoglena atra, when they are numerous. A bright orange coating is given by Stentor aureus.

The rapid and mysterious transition of colour which is observable in lakes, and which has often created an alarm in the timid minds of the superstitious inhabitants on their borders, the microscope has shewn to arise from certain changes in the condition of Infusoria. Thus, a lake of clear transparent water will assume a green colour in the course of a day; nay, more, it will become coloured and turbid in the middle of the day, when the sun brings these creatures to the surface, and rapidly develops them, or causes their dead bodies to ascend, whilst in the morning and evening it will again be clear.

The phosphorescence of the sea appears to be occasioned, in many instances, by the presence of animalcules, which, although individually imperceptible, often render luminous many miles of water by the immensity of their numbers.

In the same manner, large arborescent figures, resembling Fuci and Algæ, are formed by the Micromega; and masses of great extent by the Epistylis and Schizonema.

The Bacillaria, or their shell-like coverings (Loricæ) are often spread over many miles of the earth's surface, descending also to a considerable thickness, the remains of which, when they become indurated and mixed with

argillaceous and other earths, contract the forms of siliceous slate, porphoretic rocks, &c., present us with geological facts recorded by the Divine truth, the investigation of which, by the aid of the microscope, unlike the records of human wisdom, biassed by prejudice or alloyed by error, leaves not the shadow of a doubt upon our mind of their prior existence in another condition.

We should not omit to mention a very common mistake with respect to seeking after Infusoria. Some persons imagine that if they procure a portion of fetid ditch water, or take a few flowers and immerse them in a flower glass full of water, they will be furnished in a few days with all the varieties they may desire; the fact, however, is very different from this. It is true, that in such cases, Infusoria will be found, but they will be only of the most ordinary kinds. Those of high interest, either as regards their structure, form, or colour, like all the other masterworks of Nature and of Nature's God, are not so easily attained. Some degree of skill must be exercised for the purpose. But as we shall fully explain this matter in the section on the method of procuring and selecting Infusoria, we need not proceed further with the subject here.

Section II.—*General External Forms, Coverings, Organs, and Members of Infusoria.*

Before entering on the classification of infusorial animalcules, as determined by their *internal* structure, it will be well to make a few remarks upon their general appearance and *external* characters, as exhibited by the microscope. The forms and members of large animals may be said, in one respect, to differ but little from each other; the comparative anatomist being enabled to trace, by easy gradations, one common type throughout the whole, the varieties being occasioned by a greater development of certain parts, and the suppression of others. Such, however, is not the case with Infusoria. The general forms of Infusoria will be best conceived by a reference to the drawings, inasmuch as words would be found insufficient to convey an idea of the vast varieties which they assume. Some are egg-shaped; others resemble spheres; others, again, different kinds of fruit, eels, serpents, and many classes of the invertebrated animals, funnels, tops, cylinders, pitchers, wheels, flasks, &c. &c.

The covering, or outer tunic, of Infusoria, is of *two* kinds; the *one* soft and apparently membraneous, yielding to the slightest pressure, and accommodating itself to the state of repletion or otherwise of the animalcule, and thus resembling the tunic of the naked molusca and annelida, as slugs, leeches, &c.; the *other*, stiff, rigid, and hard, having the appearance of a shell, though, from its flexibility and transparent nature, it is more like horn. The creature identified with the former of these is termed the naked,

shell-less, or *illoricated* Infusoria, whilst the latter denotes the *loricated.* I shall, therefore, adopt the terms *loricated* and *illoricated* in this work, because they appear to be the least objectionable; for, although, in etymological strictness, *lorica* simply means a shell, yet, as we commonly attach the idea of a certain composition to the word shell, it may be as well to avoid the use of it, for the following reasons:—

The *Lorica* differs greatly as to its composition in different species. In some cases it is composed entirely of silica; in others, of lime, with a portion of the oxide of iron. In some, it is combustible; in others, not so. There is a difference also as to the proportion of envelopement of the creature within the lorica. Some Infusoria are entirely encased, as in a box or pitcher; whilst others are only so in part, having merely a shield or carapace over them. In the latter, the covering resembles that of the Chilonia or turtle tribe.

As, in very minute genera, it is often difficult to ascertain, by a mere inspection, whether they are enclosed within a lorica or not, it will not be deemed uninteresting to point out the manner in which this may be determined. Having obtained some specimens of the Infusoria, we will suppose of the family Cryptomonas (*figs.* 21 to 33), place a drop of water containing them in an aquatic live-box, compressor, or crush-box, mixing a little colouring matter with the water, according to the directions given in the section "*On feeding Animalcules with coloured Materials,*" when, if *loricated*, a clear transparent ring will be observed, encircling the animalcules, and keeping them separate from the fluid in which they are immersed:—

should this test, however, be deemed unsatisfactory, press down the cover of the aquatic live-box, so as to crush the specimens, when the coloured fluid will enter and surround their bodies, and by a proper management of the illumination of your microscope, the broken edges of the lorica will be visible, as seen in *fig.* 33, which is a representation of the Trachelomonas volvocina similarly circumstanced.

Until recently, many of the genera of the smaller kinds of animalcules were supposed to be devoid of any *external* organs whatever; but the feeding on coloured substances, and introduction of achromatic glasses, has proved the incorrectness of this conclusion, even as respects the Monads. The simplest external member, observable in the Infusoria, is a single, delicate, hair-like filament, situate near the oral orifice or mouth, and which has, consequently, been designated the *proboscis*. When this member is of an uniform appearance, it is said to be *filaform*, or thread-like; but, when it tapers toward the extremity, like an eye-lash, or cilium, it is denoted *flagelliform*. This organ is used by the animalcule both for locomotive and purveying purposes. When the creature is in rapid motion through the water, this instrument acts as an oar or paddle, in facilitating a progressive movement, whilst, at the same time, a current is created in the direction of its mouth, for the procuration of food. This member is not easily seen, inasmuch as considerable skill in the use of the microscope is required to shew it, nor will even that, in all cases, succeed. The employment of finely-divided indigo or carmine affords the surest proof of its existence. When, by this means, its action has been detected, allow the water to evaporate, and you may notice

a streak or mark, as it dries, left upon the glass, thus giving conclusive evidence of the presence of this organ. Sometimes the mouth is furnished with two of these probosces, or cilia, nearly of equal length with the body, as in the genera Chlorogonium. Other Infusoria have their oral orifices completely encircled with cilia, in which case they are usually shorter than when only one or two are perceptible, rarely exceeding one-fourth of the length of the body. Others, again, have their bodies wholly covered with cilia, which are often arranged in longitudinal rows, as with the Uroleptus. (See *Drawing*, &c.)

When these cilia are disposed in clusters, as with some of the larger polygastric animalcules, their structure may be more correctly ascertained. In the family Oxytrichina (see *Engraving*), the different modifications of these filaform organs constitute excellent characteristics of the genera; as, however, they are not limited to that particular family, I shall make a few general observations respecting them.

Cilia may be described as hairs seated upon a bulb. They perform a rapid vibratory motion, the point of each describing a comparatively large circle, whilst the base merely turns round upon its articulating surface, or part of the bulb to which it is affixed. Dr. Ehrenberg is of opinion that there are two kinds of cilia, viz. *Cilia continua,* in which the bulb is a continuation, or merely enlarged termination of the cilium; and *Cilia articulata,* in which there is a joint or articulation of the cilium to the bulb. Examples of the former may be observed in the Stylonchia mytillus; and of the latter in the Paramecium aureli, (*fig.* 330.)

It may be remarked here, that naturalists have been greatly divided in opinion with respect to the functions performed by the cilia, more especially those belonging to the Rotatoria. It has been contended by some, that these organs form the chief instrument for respiration; nor is it at all improbable that such is the case, as we find that similar ones are placed round the gills or beard of the oyster, muscle, &c., to produce currents in the water, and bring a fresh supply to the creatures. The disposition of the bundles or clusters of cilia in the Rotatoria, and their appearance when in motion, may be considered as one of the most interesting and curious spectacles in the animal creation. Their strong resemblance to toothed-wheels, and their continual revolution, have been most fertile subjects for the exercise of the imagination; indeed, there are few, if any other, which can excite more astonishment in the beholder. Let the reader turn to the various plates representing the Rotatoria, and mark the great variety of design, and exquisite beauty of execution, there displayed in the forms and dispositions of these wheel-like organs, and his mind can hardly be restrained from reverting, in the profoundest admiration, to that Divine Intelligence by which such wonders could alone have been called into existence.

Setæ, or *bristles*, are a kind of rigid hairs or cilia, used as organs for the support of the body, and for climbing, but without having the power of vibrating like real cilia. These organs are sometimes devoid of the thickened base or articulation, as with the genus Actinophrys (*fig.* 266); whilst others possess a true articulation, as exemplified in the posterior three of the Stylonchia mytillus. Some are

subulate; others have a knob at the extremity, and hence termed *capitate.*

Styles are thick straight setæ, usually seated on the under side of the body, posteriorly, and resembling the tail feathers of birds. These never vibrate; neither have they a bulbous base, nor are their extremities bent or hooked. They are used for the support of the body, and for climbing.

Uncini are curved hook-like processes, like thick short hairs. They emanate from the under surface of the body, and resemble the feet of larger animals. These organs do not vibrate, have neither bulb nor articulation, but sometimes possess considerable latitude of motion.

Variable processes are another description of external members, which perform the function of locomotion in a very complete manner. In the family Amoebaea, the animalcule appears to have the power of protruding, at pleasure, any portion of its body, to form these processes; a qualification which has not inaptly obtained for it the designation of *protean.* In the loricated family Arcellina, the variable processes are definite, the protrusion being restricted to those parts of the body which are situated near the opening in the shell, designed for that purpose. These processes, like the protean ones, are soft or membraneous, and resemble, though on a small scale, those of the Molusca, of which the horns of the common snail are a familiar example. The Infusoria, however, have a greater command than the snails, &c. have over these processes, and a more extended action, in proportion to their size.

In the Infusoria of higher organization, such as the Rotatoria, there are definite processes, of a *toe* or *claw-like*

description, which are mainly used as organs for prehension. These are generally at the extremity of a certain prolongation of the body, which may be designated a foot-like member. To the inexperienced observer, this process has generally been supposed to be the tail; but, not being placed dorsally, with respect to the discharging orifice, it must be considered as occupying the position of the foot. In these creatures, there is a large development also of those parts of the body to which the rotatory organs are attached; and, in the case where two only of these organs are seen, a projection may be noticed on each side of the anterior portion of the animalcule, such as to have obtained for them the appellation of *ears*. For example, see *fig.* 416.

Section III.—*Of the Eyes, or Visual Organs of Infusoria.*

Our knowledge of the existence of these organs is wholly attributable to the invention of the achromatic microscope. In F. O. Muller's work, which contains drawings of the larger number of the animalcules, lately figured by Dr. Ehrenberg, and several of them made with much exactness, though on a very small scale, there is not one of the Polygastrica given as possessing the visual organ, and but one species of the Rotatoria, in which he considered the existence of it as established. By referring to our engravings, however, it will be seen that nearly all the Rotatoria have eyes, and that many of the genera of the Polygastrica are also furnished with them. If no other proof than this could be obtained, therefore, of the

existence of a nervous system in these animated atoms, this might still be taken as a sufficient evidence of the fact.

Commencing, then, with the smallest, and apparently the simplest, as to organization, of the Infusoria, in which the eye is perceived, the first genera is that of the Microglena, in which instance, as in the greater number of others, the colour or pigment of it is *red*. When we reflect that in a living creature, often less than the one-thousandth part of an inch in diameter, so beautiful an organ as this exists, the inference is almost certain that there must be systems also for the performance of various other functions, but which, by their very nature, we are necessarily precluded from discerning.

By taking a glance at the tabular distribution of the genera of each family in this work—a part which is of the utmost value to the zoologist, and on which I have bestowed great pains—the reader will notice, at once, that numbers of the genera of the Polygastrica are furnished with one eye; and, in some cases, which however are more rare, with two.

In the Rotatoria, the number and position of these organs may be regarded as excellent characteristics of the genera. In the greater proportion of these, as before stated, the animalcules have two, and, in some instances, three eyes; whilst, in one genus, the Theorus, as many as seven or eight have been distinctly recognized on each side of the head. When the eyes are situated in front of the œsophagal bulb, to which the teeth are attached, they are termed *frontal eyes;* and when behind this bulb, *cervical eyes.* They are sometimes disposed in a line,

side by side, as in the Triophthalmus; and at others, arranged triangularly, as in the Eosphora. In the Cyclo-glena, they form a circle; and, in the Theorus, a cluster on each side.

Section IV.—*Distinction between the Infusoria and other Minute Animals, &c.*

In our present state of knowledge, with respect to organic bodies, there are many difficulties in the way of determining on such boundaries as may reduce them to well defined groups. Even the line of demarcation between animals and plants, which, at the first blush, might be supposed to be so very broad and distinct, upon a more minute consideration, is not easily settled. The plan of this work will comprehend a description of those creatures which are generally to be found in animal or vegetable infusions, and such as agree with them in their general structure and habits.

In *Die Infusionsthierschen,* the author has occasionally introduced animals which have been classed under other divisions of the animal kingdom. As examples, we may take the family Dinobryonia, the members of which are classed as zoophites by other naturalists. Again, in the genus Bodo, some of the species are proper Entozoa, and, therefore, ought to be excluded. Having, however, taken that work as the basis of my arrangement, all the species described therein will be found here.

With regard to the spermatozoa of animals, our knowledge of them is but scanty and confused, arising principally

from their extreme minuteness, which, even with the assistance of our most perfect microscopes, places them at the very limit of our vision. The great importance of this subject, especially to the medical professor, has obtained for it, from several distinguished naturalists, long and laborious researches; but, on the whole, the results have been so contradictory, as by no means to justify the introduction of them into this manual. It will be sufficient, therefore, to say, that since the time of their discovery (1676), up to the present period, all that we know of the *true* Spermatozoa of animals, is, that they are not distinguishable from the Cercaria found in the liver of snails, the animal organization of which has been made out by Bauer, Wagner, and Ehrenberg.

The recent discoveries of Dr. Unger on the spermatozoa of plants is a subject of such deep interest, and so little known in this country, that I have introduced a description of them under the genus Spirillum; while original drawings of them will be found in *Plate* XII.

It has been said that the line of demarcation between many species of animals and plants—the transition from the one kingdom to the other—is not easily defined. Indeed, so close is the connection between them, that some members of the families Closterina, Vibrionia, and Bacillaria, which are considered by Ehrenberg to be animals, are, by many eminent botanists, set down as belonging to the vegetable kingdom, and classed with the minute aquatic algæ of the genera Oscillatoria, Spyrogyra, &c. The true species of the two genera just named, it must be admitted, are not of animal structure; and Dr. Ehrenberg has given us the following reasons why they are not included with

the Infusoria :—1. They have no oral aperture. 2. They never propagate by direct self-division, but by the mere dissolution of the gemmæ. 3. They increase in size only by the growth of the gemmæ. 4. They have both the external and internal rigidity of vegetable organization. 5. The impregnation of the Spyrogyra resembles that of some of the species of Fungi. 6. They develope acicular crystals within themselves, like some well-known plants. 7. Their motion is not perceptibly voluntary. For further particulars, see remarks on the Closterium, Part II.

Spontaneous Generation. — Many of my readers may expect to find some notice of this subject, as the Infusoria are considered to have a *generatio primitiva,* or, in other words, are produced by some fortuitous combination of circumstances from inorganic matter. That such a statement is untenable, most persons will be inclined to admit, who have perused the description contained in the Second Part of this work. All the observations that can be depended upon tend to show that infusions of vegetable or animal matters, whether natural or artificial, only offer food for the nourishment of these living atoms, whose germs are almost everywhere present, but are only developed in situations congenial to their natures. It is now well ascertained that the old notions of certain vegetable infusions producing a definite species of Infusoria is an error ; that, in general, we have, in all artificial infusions, only common species, and that these invariably making their appearance, we may fairly presume their eggs are more generally dispersed and more readily developed. On the other hand, the Rotatoria, and more beautiful

species of Polygastrica, are confined to localities more open to the fresh air. Ehrenberg, for many years, has experimented with simple spring water, with distilled water, and rain water, and these both boiled and cold, as also with and without vegetable matter; that in open vessels, after a longer or shorter time, depending upon temperature and other circumstances, he invariably found the Infusoria; while, in closed vessels, they were rarely to be met with; so that, I think, we may consider *generatio æquivoca*, even in Infusoria, as an unphilosophical hypothesis; and that the same fixed laws of Creative Wisdom, which regulates and governs the smallest satellite and the largest starry world through boundless space, has established the same law for the developement of a living atom, as is manifested to us in the largest animal that inhabits this planet.

Section V.—*On the Method of Capturing, Selecting, and Placing Infusoria for Examination under the Microscope.*

Having provided yourself with a number of clean glass wide-mouthed phials—those containing about four ounces a-piece will be found most suitable—let them be fitted with proper corks, and not with glass stoppers. If it be required to have all the tackle neatly arranged, they may be put into a small case, expressly constructed for the purpose, and each bottle separately marked. In place of phials, however, cylindrical glass vessels, from three to five inches long, may be substituted with advantage, as they will lay better in the case, which need not exceed the dimensions of a common sandwich-box. A good walking-stick, with a

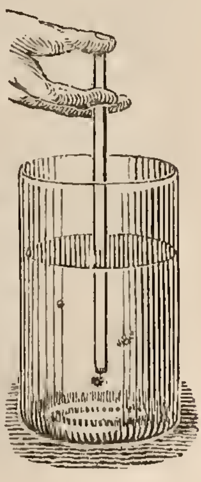
hook at the end of it, and a piece of twine, should always form part of the equipment. As the margin of small ponds is sometimes difficult of near approach, I have contrived a spring-hook, which is attached to a moveable ferule, and made to fasten to the end of the walking-stick. This lays hold of the neck of the phial, and enables you to charge it from the surface of the water, in the immediate vicinity of the stalks of water-plants, a situation generally abounding with Infusoria. Take with you, also, a pocket magnifier, of shallow power. This may be mounted in various ways; but the one I prefer is the triple, having the lenses arranged in the same plane; the convenience of which is, that you will have three different powers always ready for use, without the necessity of moving them; and that, the mounting being flat, it will be very suitable for the waistcoat pocket. Sling this, with a piece of ribbon, about the neck, and there will be no danger of losing it. The magnifying powers usually selected are those from five to fifty diameters; the first, or largest, serving to distinguish the masses; the intermediate, to show the general movements, so as to determine pretty nearly whether the water you have collected is worth retaining or not; and the smallest, or most powerful, for examining the contents with more minuteness. This latter power will not so frequently be called into use abroad as at home; because, with a little practice, the middle and shallow powers will be found to answer every purpose.

Having now mentioned all the needful apparatus, proceed to the nearest ponds of water in the neighbourhood, and should there be healthy Lemnæ on their surface, or Confervæ, or other aquatic plants, you will be almost

certain to meet with animalcules. If there be any drains, however, communicating with them, the chances are that they contain only the common species, which will, by a little practice, be readily distinguished by their motion, general appearance, and colour. The indications of the presence of Infusoria are specks moving about in the water, or an apparent mouldiness around the stalks of the Lemnæ, &c. Should these appearances not be discerned under the middle power of your magnifier, throw away the water, and repair to some more favoured pool. Be careful to take only a small portion of the vegetable matter in your vessel, as its decay, and consequent evolution of gas, may soon kill all your animalcules. This must be constantly borne in mind. Clear pools of water, in the spring of the year, are the favourite places of resort for the Volvox globator; clear water, slowly running in clay or chalky soils, for the Bacillaria and Arcellina. House gutters, and tubes placed to receive the rain water, often contain a rich supply. In the winter, you may search for them in water among dead leaves, reeds, &c., which may be taken out, and their contents shaken off into some clear water; while the species which attach themselves firmly to these objects may be examined without their being removed from them. Dr. Ehrenberg states that he has met with good success in the winter under bridges, around the piers and outworks, and even in frozen ditches beneath the ice. When you have filled your vessels, cork them carefully, so as to exclude the air, for the shaking of the carriage, when a quantity of air is left in the vessels, will often destroy them before you arrive at your place of destination. In this respect, my mode of proceeding differs from that of

Dr. Ehrenberg, who always leaves a small proportion of air in the vessel; judging, therefore, from my own experience, I should conclude that he is more careful than myself as to their conveyance. The only inconvenience I have experienced from keeping the vessels entirely filled with water, during the short time of transporting them home, has arisen from those creatures which appear to live on the surface, attaching themselves to the cork, and remaining so when required to be taken out. Remove the corks as soon as you get home, and place the vessels upright; for which a mahogany stand, furnished with a number of holes adapted for the vessels, will be very convenient. A gauze covering, fitted to the frame, will keep out the dust and blacks, without obstructing the free ingress of air.

We now proceed to the mode of investigating these minute creatures under the microscope. If the kind to be examined are those which swim freely, and are visible to the naked eye, as the Volvox, Bursaria, and other large Polygastrica, and also the free Rotatoria, take a small open glass tube, such as is described in the *Microscopic Cabinet*, p. 236, and select the specimens with it in the manner there recommended. The figure of the tube I here insert from that work. The diameters of these tubes may vary from one-eighth to one-twelfth of an inch, and their length from four to six inches. It may be useful occasionally to draw out and slightly bend the extremities which are to be immersed in the water.



When the creatures are more minute than

those above mentioned, pour a little water from the vessel containing them into a watch glass, and place it upon a piece of cardboard, rendered half *black* and half *white*. The white ground will make the dark specimens apparent, and *vice versâ;* thus, the required specimens may be taken out singly with one of the tubes, and placed in the aquatic live-box for observation. The observer will derive much assistance in this operation from the use of the pocket-magnifier before mentioned, or from a watchmaker's eye-glass.

When the Infusoria are extremely minute, they usually congregate at the edge of the water over the white portion of the cardboard, and may be removed from thence with the point of a quill, or of a small wedge-shaped pencil. If a quantity of the Chara, or other aquatic plants, be put into a glass jar with the Infusoria, in the course of a few days, more or less depending upon the temperature of the season, the surface will be covered with a thin pellicle, formed by the decomposition and extrication of gas, causing the small detached pieces of vegetable matter to float upon the water, and with them the Infusoria. Let a small portion of this film be taken from the surface, by means of the feeding pin, described in the *Microscopic Cabinet*, p. 235, and examined under the microscope, and you will hardly fail of being highly gratified. Among the most interesting genera collected from the surface of these infusions, in the manner just stated, are those belonging to the families Arcellina and Astasiæa. After the film has remained some days upon the water, many of the above-mentioned genera disappear, and are succeeded by those of the family Vibrionia, especially the Bacterium. These,

however, may be easily overlooked; for they merely resemble, even under a power of 250 diameters, seintillations, or the vibrations of eilia, among the vegetable matter. But, when earefully examined under a deeper power, they will appear like so many small short rods, eaeh rod, or ehain, having a distinet movement of its own.

SECTION VI.—*Effects of Temperature on Infusoria.*

As vitality in these ereatures is not destroyed by the ordinary eold of winter, most of the common Polygastrica may be found at that season in ponds under the iee. The Vortieella mierostoma will live after being exposed to 8° of Fah., and the iee gradually thawed; although the number in this ease may not exeeed one in a hundred. Below this temperature they will not survive. The same may be said of the Monas termo and spirillum, the Parameeium aurelium, Cyelidium glaueoma, Glaueoma seintillans, and Kolpoda eueullus. When Infusoria are destroyed by the eold, no rupture or injury will be apparent on their bodies, exeepting with the Chilodon eueullus, and some few others, which, under these eircumstances, will often beeome dissipated. The Stentor polymorphus and mulleri will not live many hours in a temperature of 9° Fah.; and arboreseent Vortieella, when subjeeted to that degree of eold, fall from the stalks and die.

The Rotatorial animaleules eannot endure so low a temperature as those above named.

When a small quantity of water, having animaleules

in it, becomes frozen, and is placed under a microscope, in a cold situation, Dr. Ehrenberg states that if the ice be clear, each animalcule or group will evidently be surrounded by an exceedingly small portion of water, which that naturalist supposes to be occasioned by the superior temperature or animal heat of the creatures preventing congelation; and he is of opinion, that in all cases where this portion of the water freezes, the animalcule necessarily dies.

If the water containing polygastric Infusoria be gradually raised to a temperature of even 125° of Fah. these creatures will live; and Dr. E. observes, that some of the Chlamidomonas pulvisculus existed, on one occasion, in water at 200° of Fah. If the increase of temperature be sudden, the animalcules die at 140°, notwithstanding it be kept up for only half a minute.

Section VII.—*Effects of Air, Chemical Mixtures, and Poisons, on Infusoria.*

That animalcules, like every other part of the animal creation, continually require fresh supplies of atmospheric air for their support, may be deduced from a variety of experiments. If a thin pellicle of oil be spread over the surface of the water in which they are retained, they very soon die from exhaustion; and indeed, it must have often happened to those who are in the habit of collecting Infusoria, that when the cork has been left, by accident, too long in a phial full of water, they have experienced this mishap. This is especially the case with

respect to the large Rotatoria: whenever experiments have been made with these creatures under an exhausted receiver, the result has invariably been that vitality ceases soon after the air has been expelled. Dr. E. states, that they exist much longer in an atmosphere of nitrogen than in carbonic acid or hydrogen. The vapour of sulphur soon puts a period to their existence.

Poisons, which only mix *mechanically* with water, do not appear to affect them materially, but those which are soluble, or combine *chemically* with it, speedily destroy their lives. Many of the Infusoria can accommodate themselves to different fluids, provided that the transition be not too sudden. Thus, similar species may be found in rivers, at their source, where the water is perfectly fresh, and at their very mouths or junction with the salt water of the ocean. Hydatinea have been fed upon powdered rhubarb without being sensibly affected by it; nor does calomel or corrosive sublimate kill them; at least they live some time after these have been mixed with the water. Strychnia causes instant death.

Section VIII.—*Effects of Electricity, Galvanism, and Magnetism, on Infusoria.*

All the experiments on record, which have been made upon animalcules with these powerful agents, appear to me to have been conducted without a due regard having been paid to their diminutive size; and hence, as might be expected, the results have proved fatal to their existence. We have, therefore, yet to learn what effects

might be produced under proper modifications. To render this proposition more intelligible, suppose, for instance, that we wished to ascertain the temperature in which fish would live, we should not expect to arrive at the desired information by plunging them suddenly into boiling water. Dr. E. has remarked that a shock from a leaden jar, charged with twenty sparks from an Electrophorus, having a resinous plate seven and a half inches square, and a collector five and a half inches, suddenly killed the Volvox globator, Stentor niger and aureus, Ampileptus moniliger, Chalamidomonas and Euglena viridis. The bodies of the Ophryoglena atra and Stentor polymorphus were entirely dissipated by it, and also those of the Epistylis flavicans, after having been first thrown from their stalks. It generally required two such shocks to kill the Paramecium aurelia. When the electrical current passes near, and not through them, their movements appear to be unsteady, in the same manner as when the mental faculties in the larger animals are disturbed. Electricity, slowly produced, has a more powerful effect than when it is accompanied with rapid sparks. If water, containing animalcules, be placed between the poles of a galvanic battery, so as to be decomposed, of course, the creatures die; and a like termination will be occasioned by magnetic currents.

For a description of an apparatus for electrifying Infusoria, see *Tracts*.

SECTION IX.—*On the Resuscitation of Infusoria.*

In almost all ages of the world there has been evinced a restless desire within us to pry into the nature or principle of *life,* and the precise conditions on which it is retained; and, notwithstanding that our bodies, its present *abiding place,* are confessedly frail and perishable, the unravelling of an invisible and immaterial agent has been sought for by a reference to them. Hence, each succeeding generation has occupied itself in proving the fallacy of preceding theories on this mysterious subject, and in forming new ones of their own. Even in modern times we have been told that dead matter, under certain circumstances, becomes spontaneously alive, such as horse-hair under water, &c. Too true it is, however, that, let our researches be what they may, unless our views are directed upwards to a higher principle than anything that we can argue upon, in what we see around us, our labours must end in nought but "vanity and vexation of spirit."

What, perhaps, has tended to awaken our inquisitiveness on this subject, more than anything else, has been that death-like condition of sleep, or suspended animation, in which human beings and other animals have been known to remain for a great length of time, during which the body is motionless, and apparently unsustained by any nourishment whatever. In 1701, Leeüwenhoek observed these appearances in the Rotatorial Infusoria; and to such an extent did his observations proceed, that

he declares they were capable of being removed from their native element, *dried up*, and preserved in this condition for months, and even years, and then resuscitated on being again moistened with water. That Rotatorial Infusoria will revive, after remaining a day or two, apparently in a dry state, I have particularly mentioned in the *Natural History of Animalcules.* The distinguished author of *Die Infusionsthierchen,* after many illustrations and comparisons made with reference to this subject, affirms, that wherever these creatures are completely desiccated, and their natural heat is gone, life can never again be restored. In this respect, they exactly correspond with animals of a larger kind; like them, for a time, they may continue in a lethargic and motionless condition, but, as it is well known, there will be going on, within them, a consumption, or wasting away of the body, equivalent to so much outward nourishment as would be needed for the sustentation of life.

Section X.—*On the Supposed Method of Manufacturing Infusoria.*

Within the last few years an idea has been prevalent, and many persons have occupied themselves in endeavouring to realize so extraordinary a discovery, that animal life may be produced by means of galvanism. The creatures said to have been thus brought into existence, that have come under my observation, were neither the most minute, nor the most simple, in organization; and evidently belonged to the class Acari. That many

scientific men should be more than sceptical upon this point, cannot be wondered at; and were it not that the notion originated with, and the experiments have been conducted by, one who holds a most honourable position amongst us, it would not have been entertained for a moment. That some mistake exists with respect to communicating vitality to matter, by this means, there cannot be a doubt.

It is not surprising that Linneus, with the imperfect microscopes of his day, should mistake Infusorial animalcules for minute drops of oil in the water; but that Dutrochet, so late as 1833, should publish to the world that all the globular and elliptical Infusoria were vesicles set in motion by streams of electricity, and therefore could be artificially produced, is but another exemplification of the fact, that men of the most distinguished talents in one department of science may form very erroneous notions on others, especially where long continued observations, and very accurate perceptions, are indispensable for arriving at right conclusions respecting them.

In 1834, Cagniard Latour made a public declaration, that he had manufactured animalcules by the aid of carburetted hydrogen. This assertion led to an examination, subsequently, of the creatures, by M. Audouin, who ascertained them to be a species of the Entomostracca, and who did not hesitate to pronounce the method, by which they were said to have been produced, to be fallacious.

The most ingenious experiment on the imaginary production of Infusoria is that of Professor Bonsdorff's, which he communicated to the German Naturalists' Asso-

ciation in 1834. The following is Ehrenberg's account of it:—"If a solution of the chloride of aluminum be dropped into a solution of potassa, by the attenuate precipitation and solution of the aluminum in the excess of alkali, an appearance will be given to the drop of aluminated matter, by the chemical changes and reactions which take place, as if the Amoeba diffluens (see description, Part II.) were actuallypresent, both as to its form and evolutions, and it will seem to be alive. Such appearance is considered, by its able discoverer, as bearing the same relationship to the real animalcule as a doll or a figure moved by mechanism does to a living child."

Section XI.—*On the Evolution of Light by Infusoria.*

Several small animals are known to emit light, apparently phosphorescent, as the female glow-worm, and some species of the Miriapoda, which I have frequently noticed in the gravel walks of a garden, on a dark autumnal evening. This emission of light, whether in the above-named animals, or in Infusoria, is evidently the result of a vital process. In the latter class of creatures, it seems like a single spark, of a moment's duration, but capable of being repeated at short intervals. That this light is electrical, analogy would lead us to infer; as experiments made upon larger creatures have proved it to be such with them.

The phosphorescence of the sea is produced by Infusoria, chiefly belonging to the family Cyclidina; and when

we take into consideration the minuteness of these creatures, the largest not exceeding the 1-100th of an inch, whilst some of them are scarcely 1-12th of that size, our ideas of computation are too limited to form any just notion of the number which sometimes illuminate many miles in extent of the ocean's surface.

Section XII.—*On the Relative Number or Abundance of different Infusoria.*

It has been stated that some species of Infusorial animalcules are more commonly met with than others, and occur in greater numbers. In the List of Species, inserted at the end of this part, those marked with a single (*) thus, are common in vegetable infusions, while those with (* *) thus, are more abundant, and those with a greater number of stars attached to their respective names are still more universally found.

The most numerous in animal infusions are those of the Monas crepusculum, Spirillum undula, Vibrio regula, Leucophrys carnium, and Polytoma uvella; in sea water, the Paramecium milium and the Stylonychia.

Section XIII.—*On the Method of Feeding Infusoria with Coloured Substances.*

Select for this purpose such coloured substances as are entirely free from metallic oxides, and not chemically soluble in water. They must, however, be capable of a

very minute mechanical division. The bodies generally used are those of carmine, indigo, and sap-green, the first being preferable. This material should be as pure as possible. Take a piece or cake of it, and rub the corner once or twice on the stage-glass, or what perhaps is better, the lower plate of an aquatic live-box, having first moistened it with a drop of water. The colouring requisite for the purpose is very small—only just sufficient to render it appreciable to the naked eye—for if there be too much, the probability is, that the particles will be too large for the creatures to imbibe. Having thus prepared the coloured food, place a drop of it beside a drop of the water containing the animalcules, but not so that they may come into contact; then put on gently the cover of the live-box, and lower it sufficiently to flatten the two drops of fluid, but not to force them to unite. Now place the live-box under the microscope, and examine the animalcules as closely as you can, and especially so as to ascertain that their stomachs are colourless; then press down the cover until the drops of fluid intermix, which may be done under the microscope, and you will immediately perceive the creatures in great activity, and readily distinguish the cilia, proboscides, and other organs, of those which possess them, and in a few seconds their stomachs will be filled with the coloured substance. Some animalcules, however, take a considerable time to effect this, but it is an exception to the general rule.

Section XIV.—*On the Mode of Drying and Preserving Infusoria.*

Although such exceedingly small creatures as animalcules, when dead, lose many of their characteristic features, especially the soft-bodied ones, yet, for the verification of some parts of their structure, it is absolutely necessary to observe them in a quiescent state; and hence, a method of effectually drying and preserving them must be considered essential. Bacellaria, in this condition, have often been preserved by botanists, in collections of minute Algæ, and with very little management; but other families will require more care. Having selected the creature you wish to preserve, remove it with a fine pointed quill, and put it on a slip of glass, or other convenient receptacle. By this means there will be but a small portion of water surrounding it, which may be extracted by some pointed pieces of ragged blotting paper. When you have withdrawn as much of the water as possible from the specimen, the remaining moisture may be readily evaporated, by placing the glass on the palm of the hand. The Hydatinea may be best preserved when destroyed with strychnia, and then rapidly dried. By what mode soever life may be taken away, it is absolutely expedient that they should be speedily and carefully dried, otherwise their bodies will be decomposed, gases evolved, and the object will fail.

The best way of mounting for the microscope dried Infusoria will be on slips of plate glass, having a polished circular cavity, in which to deposit the creatures.

These may be numbered, or otherwise marked, with a writing diamond, and a large collection of them arranged in a very compact case.

Fossil Infusoria are best preserved in Canada balsam, under thin slips of glass.

Infusoria, when simply dried, may be relaxed again by moisture, and some of them will bear this operation several times—the soft-bodied ones, however, only once. The general colour of Infusoria is retained for a considerable time after they have been dried, but the pigment of the eye is soon lost. It may be well to observe, that when the preserved specimens are intended to illustrate the nutritive system, they should be previously fed with colouring matter; but for observations on their muscular system this is not advisable.

Section XV.—*On Infusoria contained in Flints and Semi-Opals.*

It is hardly possible to take up and examine a dozen flints without discovering species of Infusoria inclosed within them. These may be best seen under the microscope, when very thin sections are made, like those of fossil woods, teeth, coal, &c.: when these are polished and cemented on glass sliders they are permanent objects. Small splinters of flint, broken off, may be used for investigation by the microscope, but such experiments are attended with very considerable danger to the object-glass of your instrument, by its being brought accidentally into contact with their sharp edges, which oftentimes cut

and injure it without your being immediately aware of the fact.

SECTION XVI.—*On Microscopes for Examining Infusoria.*

A good microscope cannot be fully appreciated until it is brought to the examination of living Infusoria. It is true, that we may make use of the scales of insects and other similar objects as tests—we may see with wonder the different markings on the surface of these dust-like atoms, but our admiration will be carried still higher, by the development of those brilliant colours and delicate tints which are discoverable in many species of the minute Infusoria. The criterion of a good microscope, then, will be, that not only the forms of these little creatures, their curious structures, organization, and digestive apparatus, are exhibited with perfect clearness, but that there is also shewn the deep and brilliant colouring of their visual organs, and the delicate tints of their variable, retractile, and locomotive processes. These living *points*—for the space they individually occupy is hardly conceivable any more than, taking the other extreme, and carrying our views over the vast expanse of the starry heavens, we can scarcely appreciate their magnitudes; and hence our thoughts are alike directed upwards to a Being, whose comprehensiveness knows no limitation or bounds. In this respect, the pursuit of the astronomer and the naturalist may be said to be the same, for both travel very far, but are ultimately lost in that infinity of purpose, to which the human intellect cannot attain. What can be more

wonderful than the contemplation of these atoms, these limits of man's perception, endued with living faculties and instincts, in all respects as perfect as those of any other created being.

The various methods of managing the microscope, and the different apparatus subsidiary to it, have been so fully expatiated upon by the late Dr. Goring, my much esteemed colleague, and myself, in our joint works, *The Microscopic Illustrations, Cabinet, Micrographia, &c.*, that it will only be necessary here to notice, briefly, a few particulars, which more especially relate to the subject before us, and to refer the reader to those works for all further information. As the expense of instruments, in the commencement of our studies, is often an important consideration, a few words on this head may not be considered inappropriate, on this occasion. Dr. Ehrenberg informs us, that he began his observations with a common microscope, and, although by his superior talent and unwearied labour, thus aided, he was enabled to make some important discoveries, yet he delayed, for some years, the publication of them, until he could verify them with better instruments.

At the period when our first publication was announced (1827) an interest in microscopic science had to be created, to which I may add, that the achromatic microscope was then in its infancy, Dr. Goring having only a short time previous (1824) discovered the conditions on which their efficacy depended, namely, *large angular aperture free from aberration.* That publication aroused the attention of scientific men to the subject, but instruments, even such as those then made, were very difficult to procure. To obviate this difficulty, Dr. Goring and

myself determined on presenting the public with detailed methods of constructing and testing achromatic microscopes. I further directed the attention of my workmen to the subject, and gave them, from time to time, such information, as, with their skill and perseverance, might advance them in this branch of art, and I believe, up to the present time, the only successful artists in this country are those who have been in my employ.

In cases where an achromatic microscope cannot be procured, recourse should be had to single lenses or doublets, for the ordinary compound, however well constructed, cannot be depended upon.

With respect to the cost of an effective microscope, with a moderate equipment of apparatus, such for example as the one described in the 6th chap. of the *Microscopic Illustrations,* which is of the best construction I have seen, the price would now be from 20 to 30 guineas. As there are a great many persons who require only a plain, sound instrument, of more moderate cost, I have deemed it expedient to take this also into consideration, and, after much application and repeated experiments, have at length produced one, in every way suitable to the case. Such is my *vertical tripod* achromatic microscope. It may be stated that nine-tenths of the observations recorded in this work may be repeated and tested by this microscope. On comparing the above instruments with that used by Dr. Ehrenberg, there is no doubt that, in point of mechanical construction, they are greatly superior, whilst the optical part is equal to any with which his researches have been made.

In adverting to this portion of my subject, I am

necessarily obliged to speak of my own productions, and even to praise them, however objectionable it may seem, and repugnant to my own feelings; but I have done so, because firmly persuaded that it will be serviceable to many persons, and this, I am sure, will be received as a sufficient apology for intruding myself into this work. In order to draw a fair comparison between different instruments, I have, at great cost, possessed myself of the best object glasses of all the foreign artists of note, and having most patiently and carefully made trial of their efficiency, no doubt rests upon my mind as to the relative qualities of each. Of the mechanical part of the continental microscopes I have elsewhere expressed an opinion.

The magnifying powers of a *complete* microscope for perfectly examining *all* kinds of Infusoria should range from 50 to 1000 diameters; and as this cannot be obtained with first-rate glasses, without recourse being had to several sets, such an instrument would be necessarily expensive. The microscope first mentioned has two or three sets of glasses, varying from 35 to 500; and the second, one set, from 80 to 300 diameters; so that, as before stated, all the most interesting observations on Infusoria may be conducted with either of these instruments, whilst additional sets may be obtained as occasion requires.

It is important to notice, that in all cases where the magnifying powers of microscopes are spoken of, the standard of sight used in computing them should be known, otherwise very erroneous ideas will be formed. In all my publications, from 1827 up to the present time,

referencc has been had to a *ten inch standard,* and the enumeration of powers has been in *diameters,* or what are sometimes termed *linear;* thus, what I compute at 100 is often spoken of as 10,000, that being the superficial measurement; ample reasons for the adoption of *linear measure,* and for that standard, are given in my works on this subject.

In demonstrating minute portions of the structures of Infusoria, a power of 800 diameters will sometimes be requisite, unless the sight be exceedingly good. I have invariably observed that aged persons require greater assistance, in this respect, than young ones. Nothwithstanding this, it will be impossible to arrive at an accurate knowledge of the creature you may be studying, even with a power of 800, unless it has been previously examined under a lower one, so that the relations of its several parts may be first clearly understood. Whenever the object in view is merely that of instructive amusement, a power of 250 diameters will be amply sufficient; that power can be managed with ease, and does not fatigue the observer. The greater number of Dr. E.'s discoveries were effected under a power of 380. I am not aware whether he has mentioned in any of his works the siderial focal length of his object-glasses, or the standard of sight. The set which Dr. E. speaks most in praise of is similar to one which I possess, and which has a focus of1-7th of an inch. He considers that with "a good achromatic microscope and a lamp, our observations may be carried on at night as well as in the day, which, by some, may be esteemed as an additional recommendation."

Section XVII.—*On Micrometers, and the Method of Measuring Infusoria.*

The late Dr. Goring, in the *Micrographia*, has described the method by which, in various ways, a correct admeasurement may be taken of these minute creatures, as also Mr. Bauer, in a paper in the same publication. I cannot do better than refer the reader to these authorities, for the fullest information attainable on this subject. A few words, however, may be said on the mode of proceeding which I have myself adopted, and which, after much practice, has been productive of very accurate results. It is as follows:—Having set up the microscope and screwed in or adapted the glasses which are intended to be used, take a glass micrometer, and place it on the stage in the same manner as if it were an object to be viewed, then carefully adjust the focus of your instrument, so that the *lines* on the micrometer may appear quite sharp and distinct. Next, take a common ruler, or a slip of card-board with equal divisions of some known measurement drawn upon it, every tenth division being longer than the rest, and fix it 20 inches from the eye, whilst looking through the microscope; then, whilst one eye is directed to the rule or card-board, and the other to the lines of the micrometer, seen in the microscope, ascertain how many on the card are equal to a given number on the micrometer. If the divisions on the latter be 1-100th of an inch, and one of them be equal to ten on the card, it is clear that every division on the card will represent

1-1000th of an inch. Thus, when the micrometer shall be removed, and an animalcule be put into its place, if the creature subtend five divisions on the card, its size in linear measure will be 5-1000th of an inch. Note—The glasses must not be changed during the experiment, nor their distances apart; neither must the distance between the card and the eye be in any way altered.

Section XVIII.—*On Glass Tubes, &c. for taking Infusoria from the Water, and placing them in the Apparatus for examination.*

As these useful little contrivances, which have been before alluded to in this Part, were drawn and described in the *Microscopic Cabinet* more than ten years ago, it will be necessary merely to mention that little or no improvement has been made upon them since that period, excepting perhaps that a *finer* description is found to answer the purpose better than when the larger ones are drawn out at their extremities in the manner there proposed.

Section XIX.—*On the Compressor, or Crush Box.*

The last remark is equally applicable to the Aquatic-live-boxes, which were described in the *Illustrations*, 1828, and subsequently their different modifications. In order to form an idea of a compressor, or crush-box, you must suppose that the cover of the live-box is so adapted

to its box by a screw, or some other convenient means, as that a small body placed under it may receive a certain degree of pressure without its parts being dislocated. In my original live-boxes, this was effected by a screw being attached to the cover; but, in the ordinary way, the cover is made to revolve. In some, a guide-piece has been substituted for the screw, so that the pressure is obtained without the glass-plates sliding one upon the other. The German opticians attach the cover or upper plate to a jointed lever, at the longest end of which a screw is applied, which brings the upper plate connected with the short-arm, in contact with the lower plate. The use of the crush-box is to protrude certain parts of the animalcule for examination by pressing down upon the creature. In this manner, the teeth of the Rotatoria become distinct. Other uses of this apparatus are given when speaking of the minute loricated Polygastrica.

Section XX.—*On Viewing Infusoria by Polarised Light.*

Having in the last edition of the *Microscopic Illustrations* given a full description of the Polarizing Microscope, and the apparatus necessary for using any microscope for polarising purposes, a very few remarks on the effects produced by viewing Infusoria under this light will be sufficient here.

The siliceous covering of Infusoria is but slightly affected by polarised light: that the effect is only feeble, is attributable to the extreme tenuity of their shells, for could we but contrive the means of magnifying the effect, I feel

convinced that some very important results would be obtained. The ribs or striæ on the navicula assume a slight tinge of colouring when the polarizer and analyzer are parallel to each other; but when they are crossed, owing to the few rays which are transmitted, I was unable to perceive it. Isthmia are slightly influenced by polarized light. The larger Infusoria I have not examined, nor am I aware that any information is recorded on this subject.

SECTION XXI.—*On Viewing Infusoria by means of the Black Ground Illumination.*

The muscular fibres of the Rotatoria, and the markings on the lorica of the Bacillaria, &c. are brought out in a most remarkable manner by this mode of illumination. For an account of the method of examining objects in this way, see *Microscopic Illustrations*, p. 138.

SECTION XXII.—*Classification of Infusoria.*

AMONG the various arrangements proposed for the distribution of animalcules by different naturalists—and we have not a few, as the minuteness of these creatures and the imperfections of our microscopes, until lately, allowed ample field for the imagination to run wild—two only appear to me to merit particular notice, and these, it is worthy of remark, are the productions of men who have laboured for years in making actual observations on them. The first is by O. F. Müller, whose posthumous work, entitled

Animalcula Infusoria Fluviatilia et Marina, appeared in the year 1786. On this arrangement is founded my *Natural History of Animalcules,* prepared in 1832; between these two periods the additions to this branch of natural history, from actual observation, was not very great; indeed, until the latter work appeared, this subject could not be said to have assumed a definite character, and was unknown to the English reader.

The laborious and long-continued observations of Dr. Ehrenberg, in Germany, have enabled him, after several revisions and amendments, to present us with a classification which, in my opinion, will remain as long our standard, on this subject, as that of Müller's has been. It is curious, however, to observe, that in all the publications, up to the present day (in England at least), professing to give an account of Dr. E.'s classification, they have taken it from his older and I may say abandoned systems.

Dr. Ehrenberg, in his great work entitled *Die Infusionsthierchen,* has not devoted much space in defining the term Infusoria, or in giving a general view of the subject; but he commences almost immediately with the class Polygastrica; hence the Second Part of this work will give the reader some idea of the general arrangement of that splendid work; though the design of the two differing, namely, the latter being a work of reference, this a manual, many alterations, omissions and additions have been made; and hence it will be alike unjust to that distinguished naturalist, as to myself, to consider the one a mere abstract of the other.

Should the reader possess a copy of the *Natural History*

of Animalcules, and will make a general comparison between the system adopted in that work and the present, he cannot fail to observe that, although the principles of the classification of Müller and Ehrenberg are widely different, yet many of the groups of animalcules occupy, as a whole, similar positions, in the two systems. This analogy I was much struck with in the place of the Vibrio of Müller and the Bacillaria of Ehrenberg, while the commencing and concluding genera in each system are similar.

Dr. E. divides the Infusoria into two grand classes; the animals belonging to the first are called *Polygastrica,* and are distinguished from the second class, named *Rotatoria,* by the function of digestion in the former being carried on by numerous globular vesicles, or stomachs, while the creatures belonging to the latter, like most large animals, have only one stomach for digestion.

Polygastrica.—The microscopic observer, having procured a number of animalcules, will not fail to observe within the interior of many a number of circular spots; these are often very large in proportion to the size of the creature, and if the water is clear, they are more transparent than the other parts of the animalcule. These vesicles the reader may readily distinguish in many of the drawings contained in the first six plates, and part of the seventh, which represent animals of the class Polygastrica. Like any other division of nature, some of the members composing it exhibit the essential characteristics of the class more prominent than others, and thus the genera Kolpoda and Paramecium contain the largest forms in which these vesicles exist. The reader will do well to refer to the drawings of these genera, which he can readily

do by means of the *List of Infusoria* I have furnished at the end of this part.

The older naturalists considered these vesicles as the ova; and Baron Gleichen made many experiments to endeavour to see their expulsion, but without success. This idea of the Baron's respecting the nature of these bodies is the more remarkable, as it is to him we owe the original experiments of feeding animalcules with coloured food; and the fact of these parts becoming immediately coloured, while the surrounding portions remain transparent, could scarcely have escaped his notice.

From the observations of Dr. E., these globular vesicles appear to be distinct stomachs, of which a single animalcule belonging to this class possesses many, as noticed in another place. When one of these stomach-cells, or sacs, has been filled with coloured food, and its situation carefully noted, in a short time the coloured spot will have changed its locality, and hence some naturalists will not admit of separate and distinct sacs or cavities, but maintain that the interior of the creature is one large digestive cavity, and that the globular mass of coloured particles has merely changed its position. To this objection, Dr. E. remarks, that he has distinctly observed a sac to fill, and then the particles to pass singly into another, and so on, until the nutritive portions having been imbibed by each cell in succession, the refuse is expelled by the animalcule. That few observers have noticed this process is not remarkable, as it requires stedfast and incessant observation of a particular animalcule for some time, while a contraction of them, or a turning upon their axis, may mislead, or even a slight pressure or

other injury loosening these cells, may occasion a voluntary change of place. Another objection to their being separate sacs or cells for the purpose of digestion is, that observers have not seen the canal or tube connecting them together; this Dr. E. admits is the case in many species, owing to its extreme tenuity. Also, that from its peculiar office, namely, the transmission of the food from one cell to another only, like the oesophagus in large animals, the tube possesses a contractile action, so that the difficulty of detection is augmented. Dr. E. affirms he has distinctly seen their canals while the food has been passing from one stomach cell to another; and in all his works, except *Die Infusionsthierchen,* has presented us with drawings of them, and the manner in which they connect all the cells together. For observations of this kind, it will be advisable to select a large specimen of either of the following species:—Chilodon cucullulus, Trachelius ovum, Vorticella chlorostigma, or convallaria, Opercularia articulata, or Stylonychia mytilus.

Again, the position of the discharging orifice has assisted in the erroneous supposition of the excluded substance being ova, for this orifice is not situated in any certain relation to the mouth; for sometimes one orifice is common to both purposes, as in the fresh water Polype, and some other large creatures. In other Polygastrica, it is either situated anteriorly, posteriorly, or laterally, and this again may be either on the superior or inferior side. On this character, Dr. E. has founded the subdivision of the class into families, as given in Part II. of this work.

Anxious to lay before the reader an impartial statement of this question, I shall, before proceeding with any

general remarks on the Polygastrica, introduce here translations of the observations of the most distinguished German botanist of the day, and likewise those of a celebrated French naturalist, while the observations of Professor Rymer Jones, the only Englishman that has given an opinion on this subject, will be found in his work, and those of naturalists relating to particular families, I have inserted under those divisions.

OBSERVATIONS ON THE DIGESTIVE ORGANS OF INFUSORIA.

By F. J. Meyen, M.D.

"All naturalists are aware that Gleichen, in 1781, tried to make certain Infusoria eat carmine, and observed next day that they had several large red granules in the interior of their bodies. He thence concluded that they had swallowed the colouring matter. He likewise noticed that these coloured granules afterwards made their escape by another opening. Gleichen has figured these red granules very accurately; each of them is in the centre of a particular circle, the nature of which he does not explain. At a later period, M. Ehrenberg made the same remark, and he thence concludes that the Infusoria have several stomachs, which, in one section, are destitute of an intestinal canal, while in others they not only possess canals, by which they communicate with each other, but lateral appendages, which besides terminate in a coecum. In consequence of these discoveries, these Infusoria were designated by the name of Polygastric animals. M.

Ehrenberg believes that he has proved that their stomachs are filled one after another, and he has figured, more or less completely, the intestines which form the communication between the different stomachs.

"Many observers have already questioned these assertions of M. Ehrenberg (see the memoir of M. Dujardin, on this subject, in the 10th volume of the *Annales des Sciences Naturelles*). For my own part, I never admitted them, because, in the first place, I never could see the intestines which form the communication between the stomachs, and likewise because I have observed, many years since, that these supposed stomachs were moving in the interior of the body of many species with great rapidity, in the same manner as the granules which circulate in the joints of the chara. I have often seen vorticelles with nine or ten large globules of indigo in the belly, which always moved round a centre, and thus shewed, in the most evident manner, that they could not have a communicating canal between the stomachs, provided with an oral orifice and an extremity directed to the mouth.

"But it will be asked, what are these vesicles and balls of the same diameter existing in the bodies of the Infusoria, and which have been taken for stomachs? This question I have continued to ask myself, till an attentive and long-continued investigation has enlightened me as to their origin.

"The true Infusoria are vesicular beings, whose interior are filled with a mucous substance; the thickness of the membrane forming the vesicle can easily be ascertained in some of these animals; and in many species I have

noticed in this membrane an obvious spiral structure, which establishes a complete analogy between it and cellular vegetables. In the large Infusoria, a cylindrical canal (the oesophagus) obliquely traverses the membrane which forms the animal. The lower extremity of this canal dilates, more or less, when the animal has taken food, even till it attains the dimensions of the balls which are found in the interior of these same Infusoria.

"The inner surface of this part of the intestinal canal is provided with cilia, which turn round not only the alimentary substances, but also foreign bodies, till they have acquired a spherical form. During the formation of this ball, the stomach (for it is evident we must distinguish this organ by that name) has a free communication with the oesophagus, and by means of the ciliary apparatus found at the exterior, new alimentary substances are introduced into this canal, and pushed as far as the stomach, but I could not satisfy myself whether the oesophagus was likewise beset with cilia in the part which separates the stomach from the buccal orifice. When the ball has acquired the size of the stomach, it is expelled by its other extremity and pushed into the cavity of the animal. It then forms a new ball, if any solid substances exist in the surrounding liquid. This second ball is itself pushed into the interior of the cavity of the animal, and drives before it the first ball along with the mucosities between the two; the successive formation of similar balls, by the matter received into the animal, continues in the same manner, without interruption. It is the simultaneous existence of many of these balls that made M. Ehrenberg believe that these animals were

polygastric. If solid substances do not exist in the surrounding liquid, then the balls are less solid, and they appear in the forms which they present in the Infusoria plunged in colourless liquids. In this case, the balls are composed of a small number of particles, and principally of a considerable mucous mass, which unites them. Sometimes two balls of this kind are so pressed against each other by the contractions of the animal, that they at last unite.

"If you wish to follow the formation of these balls, it is necessary to commence these observations at the moment when the Infusoria are plunged into the coloured liquid. The deglutition of the coloured particles takes place very quickly, often in about half a minute, and the coloured balls issue one after another from the stomach, and are pushed downwards along the internal wall of the cavity of the animal. In the genera Paramecium, Kerona, and Vorticella, the new ball pushes the preceding before it, along with the mucosities between them, in such a manner that the first rises along the opposite wall, returns to the other extremity of the cavity, and is pushed downwards on the other side. The balls thus accumulate in succession till they are expelled one after the other by the anus. The number of these balls is often so considerable, as to fill the whole cavity of the animals, and so close together, that they form a large mass, which turns slowly upon itself, as among the Vorticella.

"This rotation is the result of the force with which the newly-formed ball is pushed from the stomach into the cavity, and moves along the under side of the preceding ball. In other cases, where there are not yet

many balls, we likewise remark the circular rotation alluded to, but I cannot, in this instance, say what is the cause of it.

"Thus, in the true Infusoria, the substances which they absorb are introduced into the abdominal cavity in the form of balls, and from these the stomach extracts the nutritive substances. The residue remains in these same balls, the mucosities interposed are re-absorbed, and even in the interior of the stomach the particles of the ball are disintegrated, although this happens but seldom.

"What is the nature of those vesicular cavities, of such great numbers, and so variable in size, which appear in the interior of the Infusoria? They are not stomachs, they possess nothing in common with the balls of which we have spoken, although the latter may get into them singly, but this can only be considered as accidental.

"We may trace the formation of these cavities, and perceive their sudden and complete disappearance, with as much ease as the formation of the balls. Nay, more, it is sometimes possible to see how one of these cavities moulds itself over a ball, and speedily afterwards disappears. The microscope shows that these cavities are not lined with a particular membrane, but are mere excavations of the pulpy substance. They likewise often appear very near the inner surface of the membrane which forms the skin of the animal, and some of them increase to such a size that their diameter is equal to the third or the half of that of the entire cavity of the Infusoria. The slight refraction which the rays of light undergo at their circumference proves that these cavities are not filled with air, but by a liquid; and in the large Infusoria, it is

easy to satisfy ourselves that they do not open on the exterior. Similar cavities are formed in the mucus of true cellular plants, particularly in certain aquatic Cryptogamia.

"My botanical labours prevent me from carrying these researches farther, but enough has been said to induce the naturalist to pursue them. They require a great degree of perseverance, for it is not easy to establish these facts in all Infusoria, but they are of high importance, since the order Polygastrica has already been admitted into many modern treatises on Zoology."—(*Ed. Phil. J. vol.* xxviii.)

Resumé of "Du Jardin sur les Infusoires dans les Annales des Sciences Naturelles."

"The Infusoria (leaving out of the question the Systolides or Rotateurs, which are much more elevated in the scale of animals, and the Bacillaria, which, along with the Closteria, are more nearly related to the vegetable kingdom) have their origin, for the most part, from unknown germs, in artificial and natural infusions, stagnant water, and rivers, or such portions as rest over vegetable remains—no other mode of propagation, except self-division, being well ascertained. The fleshy substance of their bodies is dilatable and contractile, like the muscular flesh of the superior animals, but present no absolute trace of fibres or membrane, appearing, on the contrary,

homogeneous and diaphanous, save in the cases where the surface appears reticulated from contraction.

"The fleshy substance of the Infusoria, isolated by tearing, or by the death of the animalcule, appears in the liquid as lenticular discs or globules, which refract light but slightly, and are capable of forming spontaneously, in their substance, spherical cavities, analagous, in appearance, to the vesicles of the interior. The vesicles formed in the interior of the Infusoria are destitute of a proper membrane, and can contract even to so great an extent as to disappear, or many amalgate or incorporate, as it were, together. Some are produced at the base of a sort of mouth, and are destined to contain the water swallowed with the aliments; they run a long, a certain course, in the interior, and contract and leave nothing in the middle of the fleshy substance except those particles not digested, or they can evacuate their contents externally, by a fortuitous opening, which may be reproduced several times, although not identical towards the same point, and which may lead to the belief of the presence of an anus.

"The vesicles containing the aliments are independent, and neither communicate with an intestine nor with each other, save in those cases where two vesicles incorporate together.

"The other vesicles, which contain nothing but water, are formed much nearer the surface, and appear to be able to receive and expel their contents through the meshes of the tegument.

"We may consider them, along with Spallanzani, as respiratory organs, or at least as intended to multiply the points of contact of the interior substance and the surrounding fluids.

"The external organs of motion arc flagelliform filaments, or vibratile cilii, or cirri, more or less voluminous, or fleshy prolongations, which (except those which are more or less consistent) appeared formed of the same living substance, and are contractile themselves, throughout the whole of their extent. None are dermoid or corneaceous, nor secreted by a bulb, except some siliceous or horny capsule or shells, and the bundles of horny spiculi which invest the mouth of certain species. All portions of the Infusoria decompose almost immediately in water, after the death of the animal.

"The eggs of the Infusoria, their generative organs, their organs of sense, their nerves and vessels, cannot be exactly determined, and every thing inclines one to believe that these animalcules, although endowed with a degree of organization, in accordance with their mode of life, cannot possess the same systems of organs as do the superior animals."

Having presented the reader with the opponents' own arguments to the classification I have adopted, I shall proceed at once to take a general survey of this class, remarking that whatever be the fate of the Polygastrica (and some portions are certainly objectionable), I am convinced an arrangement is yet to be discovered that will supersede it.

The Polygastrica constitute a natural group of animals, and are as satisfactorily distinguished as any other class. Touching their dimensions, none exceed the 1-12th of an inch in length, and some of the smaller species (belonging to the genera Monas, Bodo, Bacterium, and the single individuals of the Vibrio,) even when full grown, are

but the 1-2000th part of that measure; indeed, so minute must be many of the young of these Infusoria, that they cannot be recognised by our microscopes. The genera Stentor and Spirostonum, on the other hand, contain species as large as the greater wheel animalcules (Rotatoria), and are easily to be distinguished by the naked eye. Again, others, individually so small as to be almost invisible, form, when aggregated, green, red, yellow, blue, brown, and black-coloured masses of great extent. Thus, the clusters of some species in the families Vorticella and Bacillaria increase to such an extent that they attain a size of several inches, resembling Polypi. The Micromega forms cartilaginous arborescent masses, which have been looked upon by some as Fuci, Algæ, &c.; Gallionella and Setrizonema, as also Epystilis grandis, often form masses several feet in length.

The greater number of animalcules belonging to this class are found in fresh water; numbers inhabit the salt water of the ocean; and some live in astringent solutions, even those containing much tannin. They are found in fluids produced by animal secretions; moist earth, too, is another situation in which some members of this class are to be found. As an instance of the later habitat, there has been recently found some earth near Newcastle almost entirely composed of living species of the genus Bacillaria, and other loricated Infusoria. It is highly probable that some kinds reside in the vapour of the atmosphere, in which, from their light weight, they may be raised in countless multitudes, and blown about by the wind in invisible cloud-like masses.

It is remarkable, that one-half the families belonging to

this class are loricated, and the other half illoricated. Of the former, the most curious discovery, of late, is that by M. Fischer, of the siliceous or glass-like covering of many species, who, although the creatures to which they belong may have been dead for thousands of years, yet these remains inform us of the local conditions of the soil at the time they existed.

These shell-like coverings are often found in large masses, covering many miles of the earth's surface, and occur, when indurated and mixed with argillaceous and other earths, in the form of siliceous slate-rocks, &c. These remains of the primeval inhabitants of our globe are records in the pages of history, penned by Infinite Truth, unbiassed by ignorance or prejudice, and form some of the first-fruits of the effective application of achromatic glasses to our microscopes.

Some of these shell-like coverings have been preserved without any admixture of other matters, and form masses of delicate white powder (*Berg-Mehl*), with which the cupidity of man, in situations where it can be procured, as Lapland, has induced him to adulterate the material which is so truly said to constitute the staff of life.

The antiquarian has also brought the microscope to bear in his researches, and by the discovery of the existence of these shelly remains in various ancient articles of pottery, and the remains of similar species in the clay in the vicinity in which they occur, has proved that they were made on the spot, and not imported from the higher civilized nations of that day, as had been previously supposed.

Section XXIII.—*Reproduction of Polygastrica.*

Monas vivipara is the only species of this class that is viviparous, though some moving granules observed amongst the Bacillaria have been supposed to extend this condition. With this exception, they may be termed oviparous, though besides the formation of eggs, which is a very fertile mode of increase, they also propagate, by means of a self-division of the body of the animalcule, into two or more individuals; also, by the growth of gemmules, or buds, upon the parent. These various modes of propagation account for their almost incomprehensible increase of number in a very short space of time, and which has often astonished observers.

In the genus Closterium, the curious formation of double gems has been observed by Ehrenberg, and is figured in plate I. *fig.* 67. That observer remarks, that this accounts for "the astonishing great fertility or capacity of increase of microscopic animals, according to which an imperceptible corpuscle can become, in four days, *one hundred and seventy billions,* or as many single individual animalcules as contained in two cubic feet of the stone from the polishing slate of Bilin. This increase takes place by voluntary division, and this is the character which separates animals from plants. It is true that the gemmation in plants, especially, in very simple cells, is at times very similar to the division in animals; but this relates to the form, not the formation. A vegetable cell, apparently capable of self-division, always became one, or contemporaneously

many exterior warts (gems), without any change in its interior. An animal, which is capable of division, first doubles the inner organs, and subsequently decreases exteriorly in size. Self-division proceeds from the interior towards the exterior, from the centre to the periphery; gemmation, which also occurs in animals, proceeds from the exterior towards the interior, and forms first a wart, which then gradually becomes organized."—(*Annals Nat. Hist.* v. ii.)

SECTION XXIV.—*Vascular System.*

In no creature of this class can a vascular system be satisfactorily demonstrated:—that thought to have been such in Paramecium aurelia was merely clusters of ova.

SECTION XXV.—*Organs of Sensation.*

Of these, the presence of eyes are all that are demonstrated, though there can be no doubt those of touch, sensation, &c., exist.

In forty-eight species, included under the families Monadina, Cryptomonadina, Volvocina, Astasiæa, Dinobryina, Peridinaea, and Kolpodea, eyes are observable, and the colour of the pigment is red in all cases, except one (Ophryoglena), in which it is almost black. In connection with the visual organs of Amblyophis and Euglena, nervous ganglia have been seen, which constitute the only traces of the evidence of a nervous system.

Section XXVI.—*Digestive System of Polygastrica.*

The most remarkable feature in this class of beings is the reception of food. In most creatures it enters one common cavity, and therefore forms one mass. In the Nais (see *Notes on Natural History*, plate 7), and some other animals, the alimentary canal is enlarged at intervals, so that it may be termed a percurrent digestive organ; but in the Polygastrica, it appears to be a very compound organ, sometimes consisting of upwards of two hundred cavities or sacs, as in the Paramecium, while the smallest number is four, and this occurs in the genus Monas.

The manner in which these sacs are arranged is various, though all may be disposed under two grand divisions, namely:—

Anentera, or those without a true alimentary canal, in which the refuse of the food is regurgitated, as in the Zoophites, of which the *fresh water Polypi* (*Notes on Nat. Hist.* pl. 6) may be taken as an example. It will appear, that the Infusoria belonging to the first twelve families include the Anentera; these possess but one orifice for the reception and expulsion of food; and although the mode in which the stomach cells are attached together is not satisfactorily determined (and this I infer from the omission of illustrative figures of structure in *Die Infusionsthierchen*), yet observation leaves little doubt that no true alimentary canal exists.

Enterodela, or those Polygastrica possessing a true alimentary canal, constitute the ten remaining families. In this division, the alimentary canal, during its course, sends forth, at intervals, short branches, each of which is termi-

nated by a digestive sac. In the families Vorticellina and Ophrydina, the two ends of the alimentary canal approach each other, and form but one external opening. In the Enchelia and Colepina, the orifices are at the opposite extremities of the body; in Trachelina, Ophryocercina, and Aspidiscina, they terminate obliquely with respect to each other; and the remaining families are distinguished from the preceding by both openings being situated on the under side of the animalcule.

Section XXVII.—*Geographical Distribution of Polygastric Infusoria.*

This is the most universal of the Animal Kingdom. It is known to extend over the whole of Europe, the north of Africa, the west and north of Asia, and species have also been observed in America. The largest and most generally-distributed family of this class is the Bacillaria, its species equalling one-fourth of the whole.

Fossil states of this curious family are known in Europe, Africa, the Isle of Bourbon, the Isle of Lucan, amongst the Philippines, and America. These remains enter into some of the new sand-stone formations; also into the layers of flints of the secondary formations, certain porphyritic structures, &c.

Some objections have been made by a few eminent naturalists to certain families of Dr. E.'s Infusoria. The most important of these I have inserted under their several heads in Part II. Those of Dr. Meyen, which are unknown to the English reader, contain many important remarks, and are worthy of special notice.

Section XXVIII.—*Class* Rotatoria.

This tribe of beings possess so complete an organization, that in a correct arrangement of the animal kingdom, it would take its station far above many others, whose members are of much larger magnitude.

The comparatively large size of the Rotatoria, the definite situation of the ova, and the simplicity of their digestive system, has enabled the microscopic observer to ascertain with certainty, in many cases, every part of their internal structure. As a tribe, it appears to me more natural than that of the Polygastrica; at least there are no such doubtful families as we find in the latter, namely, the Closterina, Bacillaria, &c. Indeed, the only exception that I think can be taken is the genus Stephanoceros, which some naturalists class along with the zoophites.

The Rotatoria mostly inhabit water; but immersion in that element does not appear to be essential to their existence. They often reside in damp or moist earth; and the Rotifer vulgaris, and some other species, are known to inhabit the cells of Mosses and Algæ.

Seection XXIX.—*Muscular System.*

In this class of Infusoria, a muscular system subservient to the functions of locomotion, nutrition, &c., is well developed, and the integuments being transparent, render their structure and situation distinctly visible under the microscope, without dissection. The principal muscular

member is a foot-like non-articulated process, situated at the ventral surface of the posterior part of the body. This member is usually called the tail; but being situated anterior to the discharging orifice, is not properly such. It has usually the faculty of being able to slide one part within another, and presents to the observer the same effect as the moving of the sliding tubes of an opera-glass, or telescope. The extremity is often formed in such a manner that the creature can cause itself to adhere to any substance, by forming an exhausted cavity within the disc-like extremity, as is the case with the leech and some parasitical acari found on beetles. Sometimes the termination of this false foot has two or more toe-like processes. By the construction of this member, the creature is enabled to attach itself, while the anterior part is moving about in search of provender, and likewise to employ it as an instrument of progression, by alternately contracting and elongating it, and fixing itself by it and the mouth. Muscles for moving the body, and also the rotatory organs, are mostly visible; these are known by their thickening during contraction, and dilating when elongated.

Section XXX.—*Nutritive System.*

The alimentary canal is mostly simple in all the Rotatorial Infusoria. It is sometimes expanded near the middle, in which case it may be said to have a true stomach, the constricted commencement being an oesophagus, and the long narrow termination a rectum.

The manducatory, or chewing apparatus, situated at the

commencement of the oesophagus, consists of a hard bulb, somewhat resembling the gizzard of birds; it is composed of two parts, the inner surface of each being, in 48 genera, furnished with teeth, which, by pressure, can be detached. Their number and arrangement form excellent characters for the systematist, and therefore I have introduced figures of them, with the oesophagal bulb, to illustrate several of the genera possessing them. This bulb, it is worthy of notice, is the first part of the young that is visible within the egg. Beneath this bulb, and attached to the oesophagus, or upper part of the stomach, is a pair of glands, usually of an oval form, sometimes, though rarely, cylindrical, or forked; these are considered as the pancreas. In some genera, gall ducts are also seen (Enteroplea). The stomach in some genera (Notommata) is furnished with biliary glands.

Section XXXI.—*The Reproductive System.*

This, in most respects, resembles that of birds, but both sexes are united in the same individual. They deposit only a few eggs at a time. The size of the egg is about 1-36th that of the parent, and the young of those in which incubation is completed before expulsion is sometimes two-thirds.

Although the Rotatorial Infusoria are not endowed with the various faculties of reproduction possessed by the Polygastrica, yet their vast increase by eggs only would astonish most persons who have not considered this subject. Dr. Ehrenberg informs us that he insulated a

single specimen of Hydatina senta, and kept it in a separate vessel for eighteen days, that during this interval it laid four eggs per day, and that these young, at two days old, lay a like number, so that, when circumstances are favourable, one million individuals are obtained from one specimen in 10 days; that, on the eleventh day, this brood will amount to four millions, and on the 12th day to sixteen millions. Although the fecundity of this Rotatoria is the greatest that has been tested by direct experiment, yet in the large Polygastrica, as the Paramecium aurelia, a single specimen in one day is ascertained to increase to eight, by simple transverse division of the body only; so that, if we take into this account the other modes of the increase of this creature, namely, by eggs, often in masses like the spawn of fish, and again by buds growing from the sides of the body, it is clear, in a very few days, all attempt at an expression of their number must fail.

Section XXXII.—*Vascular System.*

In several of the Rotatorial Infusoria are observed transverse vessels, which have the appearance of articulalations. In others, these vessels resemble a net work (see pl. ix. *fig.* 419), which is more or less distinct, below the edges of the mouth, and connected by free longitudinal ones to the interior ventral surface of the body.

Oval tremulous little bodies are in some species observed attached to a free filament-like tube (Notommata, *fig.* 416), generally disposed longitudinally within the body of the animalcules. Sometimes these little bodies are

attached to the two sexual glands (Hydatina). Dr. Ehrenberg considers their function analagous to gills, and that the tremulous motion is occasioned by the laminae, or leaflets, which compose them. For the reception of water into the interior of the body, for these organs to act upon, there is an opening at the anterior part of the body, while some species effect this purpose by means of one or two spur-like processes or tubes, emanating from the neck (see *fig.* 487), and by which water for the purpose of respiration may be admitted or rejected.

Section XXXIII.—*Organs of Sensation and Nervous System.*

The Infusoria are not considered to possess a true nervous system, but in many of the species having eyes there appears one or two masses attached to them, which Dr. E. thinks are similar to nervous ganglia and nervous fibrillae. The eyes vary in number ; they are usually of a red colour ; in some, they are placed upon a ganglion, and are freely moveable beneath the transparent superficial envelope of the body.

Section XXXIV.—*Geographical Distribution of Rotatorial Infusoria.*

So far as observation extends, they do not appear to be confined to any particular part of Europe, and they have been found in the north of Africa, the north and west of Asia, and in Carolina in America.

A LIST

OF

THE INFUSORIA

DESCRIBED IN

PART II.

SHOWING THE ORDER OF ARRANGEMENT OF THE SEVERAL FAMILIES, GENERA, AND SPECIES, AND THE DRAWINGS ILLUSTRATING THEM.

The Number preceding the Name refers to that under which it is described; the Numbers following refer to the Drawings of them in the Plates; and the stars (*) indicate those species most common in infusions.

CLASS I. POLYGASTRICA.

FAMILY I. MONADINA.

I. MONAS *Plate* I.

1 crepusculum (**), *group* 1
2 termo (***)
3 guttula (*)
4 vivipara
5 grandis
6 bicolor
7 ochracea
8 erubescens
9 vinosa
10 kolpoda
11 enchelys
12 umbra
13 hyalina
14 gliscens (*)
15 ovalis
16 mica
17 punctum, *group* 2
18 cylindrica
19 Okenii
20 deses
21 socialis
22 flavicans
23 simplex
24 inanis
25 scintillans
26 Dumalii

II. UVELLA *Plate* I.

27 virescens
28 chamaemorum
29 uva
30 atomus
31 glaucoma (**), *cluster* 3, and *fig.* 4, 5, 6
32 bodo

III. POLYTOMA

33 uvella, *fig.* 7, 8, 9, 10, 11

IV. MICROGLENA

34 punctifera
35 monadina, *fig.* 12, 13, 14

V. PHACELOMONAS

36 pulvisculus

VI. GLENOMORUM

37 tingens, *fig.* 15, 16, 17

VII. DOXOCOCCUS

38 globulus
39 ruber, *group*
40 pulvisculus
41 inaequalis

VIII. CHILOMONAS *Plate* I.
42 volvox
43 paramecium (*), *group* 19
44 destruens

IX. BODO
45 socialis (**)
46 vorticellaris

BODO *Plate* I.
47 didymus
48 saltans (*)
49 grandis
50 intestinalis, *group* 20
51 ranarum
52 viridis
53 oystea

FAMILY II. CRYPTOMONADINA.

X. CRYPTOMONAS
54 curvata
55 ovata, *fig.* 21, 22, 23
56 erosa
57 cylindrica
58 ? glauca
59 ? fusca
60 lenticularis

XI. OPHIDOMONAS
61 jenensis

XII. PROROCENTRUM
62 micans, *fig.* 24, 25

XIII. LAGENELLA
63 euchlora, *fig.* 26, 27, 28

XIV. CRYPTOGLENA
64 conica, *group* 29
65 pigra
66 carulescens

XV. TRACHELOMONAS
67 nigricans
68 volvocina, *fig.* 30 to 33
69 cylindrica

FAMILY III. VOLVOCINA.

XVI. GYGES
70 granulum, *fig.* 34
71 bipartitus
72 sanguineus, [*plate* xii. *group* 532]

XVII. PANDORINA
73 morum, *fig.* 35, 36, 37
74 ? hyalina

XVIII. GONIUM
75 pectorale, *fig.* 38 to 42
76 punctatum
77 ? tranquillum, *fig.* 43
78 ? hyalinum
79 ? glaucum

XIX. SYNCRYPTA
80 volvox, *fig.* 44, 45, 46

XX. SYNURA
81 uvella, *fig.* 50, 51

XXI. UROGLENA
82 volvox, *fig.* 53, 54

XXII. EUDORINA
83 elegans, *fig.* 47

XXIII. CHLAMIDOMONAS
84 pulvisculus (**), *group* 52

XXIV. SPHAEROSIRA
85 volvox, *fig.* 48, 49

XXV. VOLVOX
86 globator, *fig.* 55, 56, 57
87 aureus
88 stellatus

FAMILY IV. VIBRIONIA.

XXVI. BACTERIUM
89 triloculare (*), *group* 58
90 ? enchelys
91 ? punctum

XXVII. VIBRIO
92 lineola (**)
93 tremulans (*)
94 subtilis
95 rugula (***)
96 prolifer
97 bacillus (*), *group* 59

XXVIII. SPIROCHAETA
98 plicatilis, *fig.* 60

XXIX. SPIRILLUM
99 tenue
100 undula (**), *fig.* 61
101 volutans (*)
102 bryozoon, [*plate* xii.] *fig.* 520 to 531

XXX. SPIRODISCUS
103 fulvus, *fig.* 62

FAMILY V. CLOSTERINA.

XXXI. CLOSTERIUM *Plate* I.
104 lunula
105 moniliferum
106 Dianae
107 acerosum, *fig.* 63, 64, 65
108 trabecula
109 digitus
110 attenuatum
111 cornu

CLOSTERIUM *Plate* I.
112 ? cylindrus
113 margaritaceum
114 turgidum, *fig.* 66
115 lineatum
116 striolatum
117 setaceum, *group* 67
118 rostratum
119 ? inaequale

FAMILY VI. ASTASIAEA.

XXXII. ASTASIA
120 haematodes, *fig.* 68
121 flavicans
122 pusilla, *fig.* 69
123 ? viridis
124 navalis, [*plate* xii.] *fig.* 533

XXXIII. AMBLYOPHIS
125 viridis, *fig.* 70

XXXIV. EUGLENA
126 sanguinea, *fig.* 71, 72, 73
127 hyalina
128 deses
129 viridis
130 spirogyra
131 pyrum, *group* 74
132 pleuronectes

EUGLENA
133 longicauda, *fig.* 75, 76
134 triquetra, 77
135 acus, *group* 78
136 rostrata

XXXV. CHLOROGONIUM
137 euchlorum, *group* 79

XXXVI. COLACIUM
138 ? vesiculosum, *group* 80
139 stentorinum

XXXVII. DISTIGMA *Plate* II.
140 ? tenax
141 proteus, *group* 81
142 viride
143 planaria
144 dinobryina

FAMILY VII. DINOBRYONIA.

XXXVIII. EPIPYXIS *Plate* II.
145 utriculus, *group* 82

XXXIX. DINOBRYON
146 sertularia, *fig.* 83, 84
147 ? sociale

FAMILY VIII. AMOEBAEA.

XL. AMOEBA
148 princeps, *fig.* 85, 86, 87
149 verrucosa

AMOEBA
150 diffluens
151 radiosa, *fig.* 88, 88′

FAMILY IX. ARCELLINA.

XLI. DIFFLUGIA
152 proteiformis, *fig.* 89 to 91
153 oblonga
154 acuminata
155 enchelys

XLII. ARCELLA
156 vulgaris

ARCELLA
157 aculeata, *fig.* 92, 93, 94
158 dentata
159 ? hyalina

XLIII. CYPHIDIUM
160 aureolum, *fig.* 95 to 98

FAMILY X. BACILLARIA.

XLIV. DESMIDIUM
161 Swartzii
162 orbiculare
163 hexaceros, *group* 99
164 bifidum
165 aculeatum

DESMIDIUM
166 apiculosum

XLV. STAURASTRUM
167 dilatatum, *fig.* 100, 101
168 paradoxum, *fig.* 102, 103

XLVI. PENTASTERIAS *Plate* II.
169 margaritacea, *fig.* 104

XLVII. TESSARARTHRA
170 moniliformis, *fig.* 105, 106

XLVIII. SPHAERASTRUM
171 pictum
172 quadrijugum

XLIX. XANTHIDIUM
173 hirsutum [*plate* xii.] *fig.* 512
174 aculeatum, *fig.* 109
175 fasciculatum
176 furcatum, *fig.* 110
177 ? ramosum, *fig.* 511, 515
178 ? difforme, *fig.* 111, 513, 514
179 crassipes
180 tubiferum

L. ARTHRODESMUS
181 quadricaudatus
182 pectinatus
183 acutus
184 convergens, *fig.* 112, 113
185 octocornis
186 truncatus

LI. ODONTELLA
187 desmidium, *fig.* 108
188 ? filiformis, *fig.* 107
189 ? unidentata

LII. MICRASTERIAS
190 tetras
191 coronula
192 Napoleonis (hexaetis), *fig.* 117, 118
193 heptactis, *fig.* 114
194 Boryana, *fig.* 115, 116
195 angulosa
196 rotula
197 tricyclia
198 elliptica

LIII. EUASTRUM
199 rota, *fig.* 121, 122, 123
200 apiculatum
201 crux melitensis, *fig.* 124
202 pecten
203 verrucosum, *fig.* 125
204 ansatum
205 margaritiferum *fig.* 126
206 botrytis
207 integerrimum

LIV. MICROTHECA
208 octoceros, *fig.* 119, 120

LV. PYXIDICULA
209 operculata, *group* 127
210 globator, [*plate* xii.] *fig.* 506 to 510.

LVI. GALLIONELLA *Plate* III.
211 lineata, *fig.* 128
212 nummuloides
213 varians, *group* 131
214 moniliformis
215 aurichalcea
216 ferruginea, [*plate* ii.] *fig.* 129, 130
217 distans
218 sulcata, [*plate* iii.] *group* 131

LVII. ACTINOCYCLUS
219 senarius, *group* 132
220 octonarius

LVIII. NAVICULA *Plate* III.
221 Phoenicenteron, *group* 139
222 gracilis
223 ? pellucida, *group* 140
224 acus, *group* 147
225 umbonata
226 fulva
227 amphisbaena, *group* 141
228 platystoma, *fig.* 142
229 nodosa, *fig.* 143
230 trochus
231 follis
232 trinodis
233 cari
234 ? quadricostata
235 baltica, *fig.* 144
236 hippocampus, *group* 145
237 sigma, *group* 146
238 scalpum
239 curvula
240 arcus
241 sigmoidea, *group* 148
242 viridis, *fig.* 133 to 136
243 macilenta
244 viridula
245 inaequalis, *group* 154
246 gibba
247 ? crux
248 ? glans
249 capitata
250 dicephala
251 lanceolata
252 ? librile, *group* 155
253 ? splendida, *fig.* 150 to 152
254 ? bifrons
255 striatula, *fig.* 137, 138
256 ? undulata, *fig.* 149
257 ? constricta
258 ? amphora, *fig.* 153
259 ? lineolata

LIX. EUNOTIA *Plate* III.

260 turgida, *fig.* 156 to 161, except in *group* 157, those marked by a cross
261 Westermanni, in *group* 157, those figures marked by a cross
262 zebra
263 granulata, *fig.* 165
264 ? faba
265 arcus
266 diodon
267 triodon, *group* 164
268 tetraodon
269 pentodon
270 diadema
271 serra

LX. COCCONEÏS

272 scutellum, *fig.* 162, 163
273 undulata
274 placentula
275 pediculus
276 ? finnica
277 ? clypeus [*plate* xii.] *fig.* 516 to 518

LXI. BACILLARIA

278 paradoxa, *fig.* 166, 167
279 vulgaris, *fig.* 168
280 pectinalis
281 elongata, *fig.* 169
282 cuneata, *fig.* 170
283 Cleopatrae
284 ? tabellaris
285 flocculosa
286 seriata
287 Ptolemaei

LXII. TESSELLA

288 catena, *fig.* 180 to 182
289 arcuata
290 interrupta

LXIII. FRAGILARIA

291 grandis, *fig.* 171
292 rhabdosoma, *fig.* 173, 174
293 turgidula, *group* 172
294 multipunctata
295 bipunctata, *fig.* 175
296 angusta
297 scalaris
298 diopthalma
299 pectinalis, *fig.* 176

LXIV. MERIDION

300 vernale, *fig.* 177 to 179
301 ? panduriforme

LXV. ISTHMIA *Plate* IV.

302 obliquata
303 enervis, *fig.* 183

LXVI. SYNEDRA

304 ulna, *group* 184
305 capitata, *group* 185′
306 gallionii
307 fasciculata
308 lunaris, *group* 185
309 bilunaris

LXVII. PODOSPHENIA

310 gracilis, *fig.* 186
311 abbreviata
312 cuneata
313 ? nana

LXVIII. GOMPHONEMA

314 truncatum, *fig.* 187 to 190
315 capitatum
316 gracile
317 acuminatum
318 minutissimum
319 clavatum
320 rotundatum
321 discolor
322 ? olivaceum

LXIX. ECHINELLA

323 flabellata, *fig.* 191 to 193
324 splendida
325 ? paradoxa
326 capitata
327 ? abbreviata
328 fulgens

LXX. COCCONEMA

329 Boeckii
330 lanceolatum, *fig.* 194, 195
331 cistula, *fig.* 196 to 198
332 cymbiforme
333 ? gibbum
334 ? fusidium

LXXI. ACHNANTHES

335 longipes
336 brevipes, *fig.* 199 to 202
337 subsessilis
338 exilis
339 minutissima
340 ? inaequalis

LXXII. STRIATELLA

341 arcuata, *fig.* 203, 204

LXXIII. FRUSTULIA

342 appendiculata
343 maritima
344 salina

LXXIV. SYNCYCLIA *Plate* IV.
345 salpa, *group* 206

LXXV. NAUNEMA
346 simplex
347 Dillwynii
348 Hoffmanni
349 arbuscula
350 balticum, *fig.* 207

LXXVI. GLOEONEMA
351 paradoxum

Plate IV.
LXXVII. SCHIZONEMA
352 ? Agardhi, *fig.* 208

LXXVIII. MICROMEGA
353 corniculatum

LXXIX. ACINETA
354 lyngbyi
355 tuberosa
356 mystacina, *fig.* 205

FAMILY XI. CYCLIDINA.

LXXX. CYCLIDIUM
357 glaucoma, *fig.* 209 to 211
358 margaritaceum
359 ? planum
360 ? lentiforme

LXXXI. PANTOTRICHUM
361 enchelys, *fig.* 212

PANTOTRICHUM
362 volvox
363 lagenula

LXXXII. CHAETOMONAS
364 globulus, *fig.* 213
365 constricta

FAMILY XII. PERIDINAEA.

LXXXIII. CHAETOTYPHLA
366 armata, *fig.* 214, 215
367 aspera
368 ? pyritae

LXXXIV. CHAETOGLENA
369 volvocina, *fig.* 216 to 218

LXXXV. PERIDINIUM
370 cinctum
371 pulvisculus
372 fuscum
373 ? pyrophorum

PERIDINIUM
374 ? delitiense
375 acuminatum
376 cornutum
377 tripos, *fig.* 219, 220
378 Michaelis, *fig.* 221
379 fusus, *fig.* 222, 223
380 furca

LXXXVI. GLENODINIUM
381 cinctum
382 tabulatum
383 apiculatum, *fig.* 224 to 226

FAMILY XIII. VORTICELLINA.

LXXXVII. STENTOR
384 Mülleri
385 Roeselii, *fig.* 233, 234
386 caeruleus, [*plate* v.] *fig.* 235, 236
387 polymorphus
388 igneus
389 niger

LXXXVIII. TRICHODINA ?
390 tentaculata, [*plate* iv.] *fig.* 227
391 pediculus, *fig.* 228 to 230
392 vorax
393 grandinella (*)

LXXXIX. UROCENTRUM
394 turbo, *fig.* 232, 232

XC. VORTICELLA
395 nebulifera.
396 citrina
397 microstoma (**)
398 campanula
399 hamata
400 chlorostigma
401 patellina (*)
402 convallaria, [*plate* v.] *fig.* 237, 238, 239
403 picta

XCI. CARCHESIUM
404 polypinum, *fig.* 240 to 245

XCII. EPISTYLIS
405 galea
406 anastatica

EPISTYLIS *Plate* V.

407 plicatilis
408 grandis
409 flavicans
410 leucoa
411 digitalis
412 ? nutans, *fig.* 245, 246
413 botrytis
414 ? vegetans

EPISTYLIS *Plate* V.

415 ? parasitica
416 arabica

XCIII. OPERCULARIA

417 articulata

XCIV. ZOOTHAMNIUM

418 arbuscula, *fig.* 247, 248
419 niveum

FAMILY XIV. OPHRYDINA.

XCV. OPHRYDIUM

420 versatile, *fig.* 249 to 254

XCVI. TINTINNUS

421 inquilinus, *group* 255
422 subulatus

XCVII. VAGINICOLA

423 crystallina

VAGINICOLA

424 tincta
425 decumbens, *group* 256

XCVIII. COTHURNIA

426 imberbis, *group* 257
427 maritima
428 havniensis

FAMILY XV. ENCHELIA.

XCIX. ENCHELYS

429 pupa, *fig.* 258, 259
430 farcimen, *fig.* 260 to 265
431 infuscata
432 nebulosa

C. DISOMA

433 vacillans, 265′

CI. ACTINOPHRYS

434 sol
435 viridis, *fig.* 266
436 difformis

CII. TRICHODISCUS

437 sol, *fig.* 267, 268

CIII. PODOPHRYA

438 fixa, *fig.* 269, 270

CIV. TRICHODA

439 pura (*) *fig.* 271 to 273
440 nasamonum
441 ovata
442 ? aethiopica

TRICHODA

443 asiatica
444 pyrum

CV. LACRYMARIA

445 proteus, *fig.* 274, 275
446 gutta
447 rugosa

CVI. LEUCOPHRYS

448 patula, *fig.* 276, 277
449 spathula *fig.* 278
450 sanguinea, *fig.* 279, 280
451 pyriformis (**)
452 carnium (**)
453 ? anodontae

CVII. HOLOPHRYA

454 ovum, *fig.* 281
455 discolor
456 coleps

CVIII. PRORODON

457 niveus
458 teres, *fig.* 282, 283

FAMILY XVI. COLEPINA.

CIX. COLEPS

459 hirtus (*) *fig.* 284 to 286
460 viridis
461 elongatus

COLEPS

462 amphacanthus
463 incurvus

FAMILY XVII. TRACHELINA.

CX. TRACHELIUS

464 anas, *fig.* 287, 287′, 288, 289
465 vorax
466 meleagris
467 lamella (***)
468 anaticula
469 ? trichophorus

TRACHELIUS

470 ? globulifer
471 ovum, *fig.* 290

CXI. LOXODES

472 rostrum, *fig.* 291 to 293
473 cithara

LOXODES *Plate* VI.
474 bursaria
475 plicatus

CXII. BURSARIA
476 truncatella
477 vorticella, *fig*. 294
478 vorax
479 entozoon
480 intestinalis
481 ? cordiformis
482 lateritia
483 vernalis
484 leucas, *fig*. 295
485 pupa, *fig*. 296
486 flava
487 nucleus
488 ranarum
489 ? aurantiaca

CXIII. SPIROSTOMUM
490 virens, *fig*. 296′

SPIROSTOMUM *Plate* VI.
491 ambiguum, *fig*. 297, 298

CXIV. PHIALINA
492 vermicularis
493 viridis, *fig*. 299

CXV. GLAUCOMA
494 scintillans (*) *fig*. 300, 301, 302

CXVI. CHILODON
495 cucullulus (***) *fig*. 303 to 309
496 uncinatus
497 aureus
498 ornatus

CXVII. NASSULA
499 elegans, *fig*. 310, 311
500 ornata
501 aurea

FAMILY XVIII. OPHRYOCERCINA.

CXVIII. TRACHELOCERCA
502 olor, *fig*. 317, 318, 319

TRACHELOCERCA
503 viridis
504 biceps, *fig*. 320

FAMILY XIX. ASPIDISCINA.

CXIX. ASPIDISCA
505 lynceus

ASPIDISCA *Plate* VII.
506 denticulata, *fig*. 321, 322, 323

FAMILY XX. KOLPODEA.

CXX. KOLPODA
507 cucullus (***) *fig*. 324 to 328
508 ? ren
509 ? cucullio

CXXI. PARAMECIUM
510 aurelia (***) *fig*. 329 to 332
511 caudatum
512 chrysalis (***)
513 kolpoda (*)
514 ? sinaiticum
515 ? ovatum
516 compressum
517 milium (**)

CXXII. AMPHILEPTUS
518 anser, *fig*. 312, 313
519 margaritifer
520 moniliger

AMPHILEPTUS *Plate* VI.
521 viridis
522 fasciola, *fig*. 314, 315, 316
523 meleagris
524 longicollis
525 papillosus

CXXIII. UROLEPTUS *Plate* VII.
526 piscis
527 musculus, *fig*. 333
528 hospes
529 ? lamella
530 filum

CXXIV. OPHRYOGLENA
531 atra
532 acuminata, *fig*. 334, 335
533 flavicans

FAMILY XXI. OXYTRICHINA.

CXXV. OXYTRICHA
534 rubra
535 pellionella (**)
536 caudata
537 platystoma
538 gibba, *fig*. 336, 337
539 pullaster

OXYTRICHA
540 cicada
541 lepus

CXXVI. CERATIDIUM
542 cuneatum, *fig*. 338, 339

CXXVII. KERONA
543 polyporum, *fig*. 340, 341

CXXVIII. Urostyla *Plate* VII.
544 grandis, *fig.* 342

CXXIX. Stylonychia
545 mytilus (*)
546 pustulata (**)

Stylonychia *Plate* VII.
547 silurus
548 appendiculata
549 histrio
550 lanceolata, *fig.* 343, 344

FAMILY XXII. EUPLOTA.

CXXX. Discocephalus
551 rotatorius, *fig.* 345, 346

CXXXI. Himantophorus
552 charon, *fig.* 347, 348

CXXXII. Chlamidodon
553 mnemosyne, *fig.* 349

CXXXIII. Euplotes
554 patella

Euplotes
555 charon (**) *fig.* 350 to 353
556 striatus
557 appendicutalus
558 truncatus
559 monostylus
560 aculeatus
561 turritus
562 cimex

CLASS II. ROTATORIA.

FAMILY XXIII. ICHTHYDINA.

CXXXIV. Ptygura
563 melicerta, *fig.* 354, 355

CXXXV. Ichthydium
564 podura (*) *fig.* 356

CXXXVI. Chaetonotus
565 maximus

Chaetonotus
566 larus, *fig.* 357, 358
567 brevis

CXXXVII. Glenophora
568 trochus, *fig.* 359, 360

FAMILY XXIV. OECISTINA.

CXXXVIII. Oecistes
569 crystallinus, *fig.* 361 to 364

CXXXIX. Conochilus
570 volvox, *fig.* 365 to 370

FAMILY XXV. MEGALOTROCHAEA.

CXL. Cyphonautes
571 compressus, [*plate* viii.] *fig.* 373

CXLI. Microcodon
572 clavus, *fig.* 371, 372

Plate VIII.

CXLII. Megalotrocha
573 albo flavicans, *fig.* 374, 375, 376, 377

FAMILY XXVI. FLOSCULARIA.

CXLIII. Tubicolaria
574 najas, *fig.* 379 to 382

CXLIV. Stephanoceros
575 Eichhornii, *fig.* 383, 383*

CXLV. Limnias
576 ceratophylli, *fig.* 388 to 392

CXLVI. Lacinularia
577 socialis, *fig.* 378

CXLVII. Melicerta
578 ringens, *fig.* 386, 387

CXLVIII. Floscularia
579 proboscidea
580 ornata, *fig.* 384, 385

FAMILY XXVII. HYDATINAEA.

CXLIX. Enteroplea
581 hydatina, *fig.* 393

CL. Hydatina
582 senta, *fig.* 394
583 brachydactyla

CLI. Pleurotrocha
584 gibba, *fig.* 395, 396
585 constricta
586 leptura

Plate IX.

CLII. Furcularia
587 gibba
588 Reinhardti, *fig.* 397, 398
589 forficula
590 gracilis

CLIII. Monocerca
591 rattus
592 bicornis, *fig.* 399, 417
593 ? valga

CLIV. Notommata
594 myrmelco, *fig.* 418 to 420
595 syrinx
596 hyptopus
597 parasita
598 granularis
599 petromyzon
600 lacinulata
601 forcipata
602 collaris
603 Werneckii
604 najas
605 aurita
606 gibba
607 ansata
608 decipiens
609 ? felis
610 ? tigris,
611 longiseta *fig.* 421
612 aequalis
613 clavulata
614 tuba
615 brachionus
616 tripus
617 saccigera
618 copeus, *fig.* 416
619 centrura
620 brachyota

CLV. Synchaeta
621 pectinata *fig.* 422
622 baltica
623 oblonga
624 tremula

Plate IX.

CLVI. Scaridium
625 longicaudum, *fig.* 423, 424

CLVII. Polyarthra
626 trigla, *fig.* 400, 401, 425
627 platyptera *fig.* 402

CLVIII. Diglena?
628 lacustris, *fig.* 403
629 grandis, *fig.* 404, 405
630 forcipata
631 aurita
632 catellina
633 conura
634 capitata
635 caudata

CLIX. Triarthra
636 longiseta *fig.* 406 to 408
637 mystacina

CLX. Rattulus
638 lunaris, *group* 409

CLXI. Distemma
639 forficula, *fig.* 410, 411
640 setigerum
641 ? marinum
642 ? forcipatum

CLXII. Triopthalmus
643 dorsualis, *fig.* 412 to 414

CLXIII. Eosphora
644 najas, *fig.* 415
645 digitata
646 elongata

CLXIV. Otoglena
647 papillosa

CLXV. Cycloglena
648 lupus, [*plate* x.] *fig.* 425,* 426
649 ? elegans

CLXVI. Theorus
650 vernalis *fig.* 427 to 429
651 uncinatus

FAMILY XXVIII. EUCHLANIDOTA.

CLXVII. Lepadella
652 ovalis (**) *fig.* 430 to 433
653 emarginata
654 ? salpina

CLXVIII. Monostyla
655 cornuta
656 quadridentata, *fig.* 434 to 437
657 ? lunaris

CLXIX. Mastigocerca
658 carinata, *fig.* 438 to 440

CLXX. Euchlanis
659 ? triquetra, *fig.* 441 to 444
660 ? Hornemanni
661 luna
662 macrura
663 dilatata
664 lynceus, *fig.* 445, 446

CLXXI. SALPINA *Plate* X.
665 mucronata, *fig.* 447 to 453
666 spinigera
667 ventralis
668 redunca
669 brevispina
670 bicarinata

CLXXII. DINOCHARIS
671 pocillum, *fig.* 454 to 456
672 tetractis
673 paupera

CLXXIII. MONURA.
674 colurus
675 dulcis, *fig.* 457 to 459

CLXXIV. COLURUS
676 ? uncinatus (**)

COLURUS *Plate* X.
677 ? bicuspidatus
678 caudatus
679 deflexus, *fig.* 460 to 462

CLXXV METOPIDIA
680 lepadella, *fig.* 463 to 465
681 acuminata
682 triptera

CLXXVI. STEPHANOPS
683 lamellaris, *fig.* 466, 467
684 ? muticus
685 cirratus

CLXXVII. SQUAMELLA
686 bractea
687 oblonga, *fig.* 468, 469

FAMILY XXIX. PHILODINAEA.

Plate XI.

CLXXVIII. CALLIDINA
688 elegans, *fig.* 470 to 473

CLXXIX. HYDRIAS
689 cornigera, [*plate* xi.] *fig.* 474

CLXXX. TYPHLINA
690 viridis, *group* 475

CLXXXI. ROTIFER
691 vulgaris, *fig.* 476 to 480
692 ? citrinus
693 ? erythraeus
694 macrurus
695 tardus

CLXXXII. ACTINURUS
696 Neptunius, *fig.* 481 to 484

CLXXXIII. MONOLABIS
697 conica *fig.* 485, 486
698 gracilis

CLXXXIV. PHILODINA
699 erythropthalma
700 roseola, *fig.* 490
701 collaris
702 macrostyla
703 citrina
704 aculeata, *fig.* 487 to 489
705 megalotrocha

FAMILY XXX. BRACHIONAEA.

CLXXXV. NOTEUS
706 quadricornis, *fig.* 491 to 494

CLXXXVI. ANURAEA
707 ? quadridentata
708 squamula, *fig.* 495 to 497
709 falculata
710 curvicornis
711 biremis
712 striata
713 inermis
714 acuminata
715 foliacea
716 stipitata, *fig.* 498
717 testudo
718 serrulata
719 aculeata
720 valga

CLXXXVII. BRACHIONUS
721 pala
722 amphiceros
723 urceolaris
724 Rubens
725 Mülleri
726 brevispinus
727 Bakeri
728 polyacanthus, *fig.* 499 to 501
729 militaris

CLXXXVIII. PTERODINA
730 patina, *fig.* 502 to 504
731 elliptica
732 clypeata, *fig.* 505

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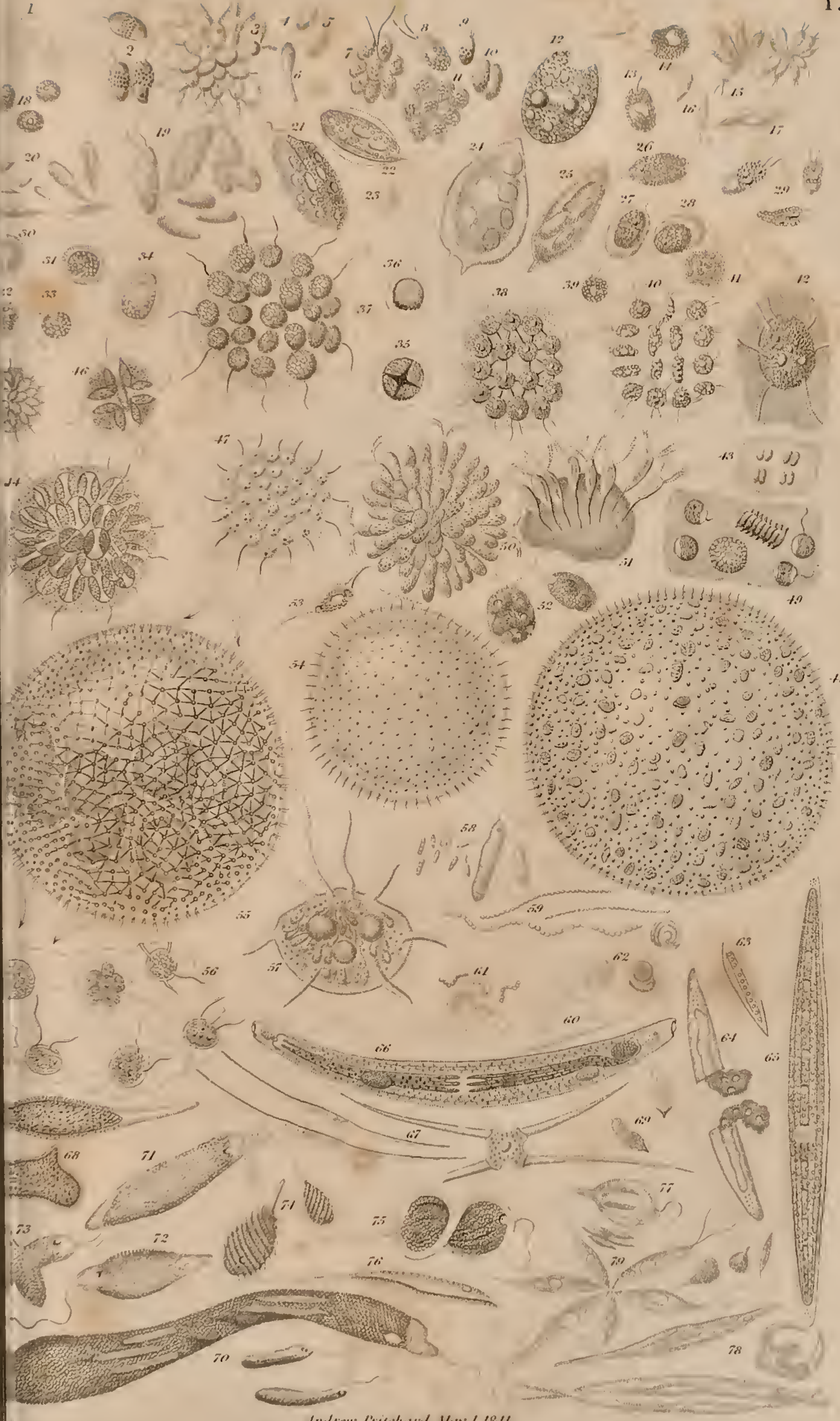

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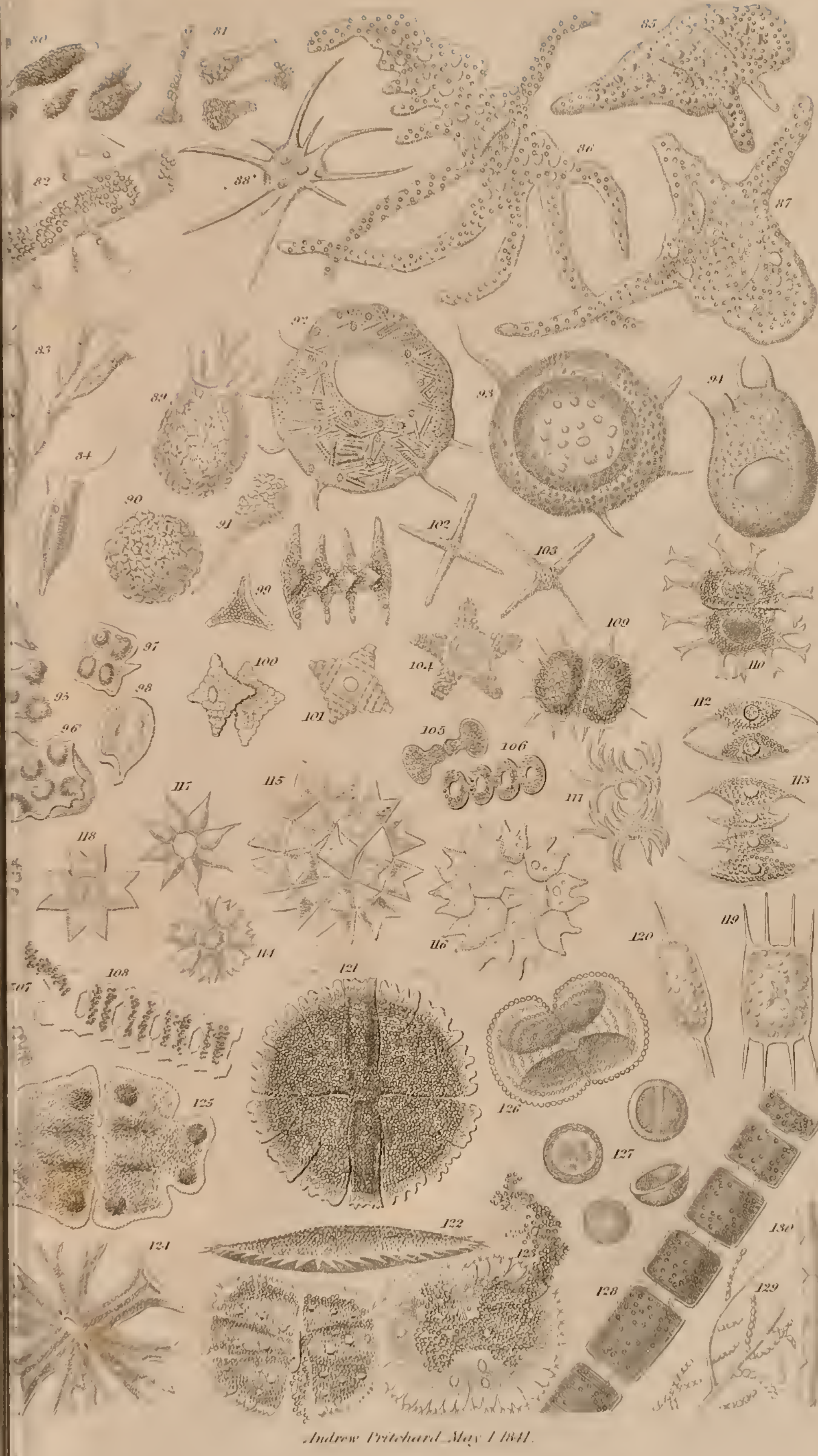

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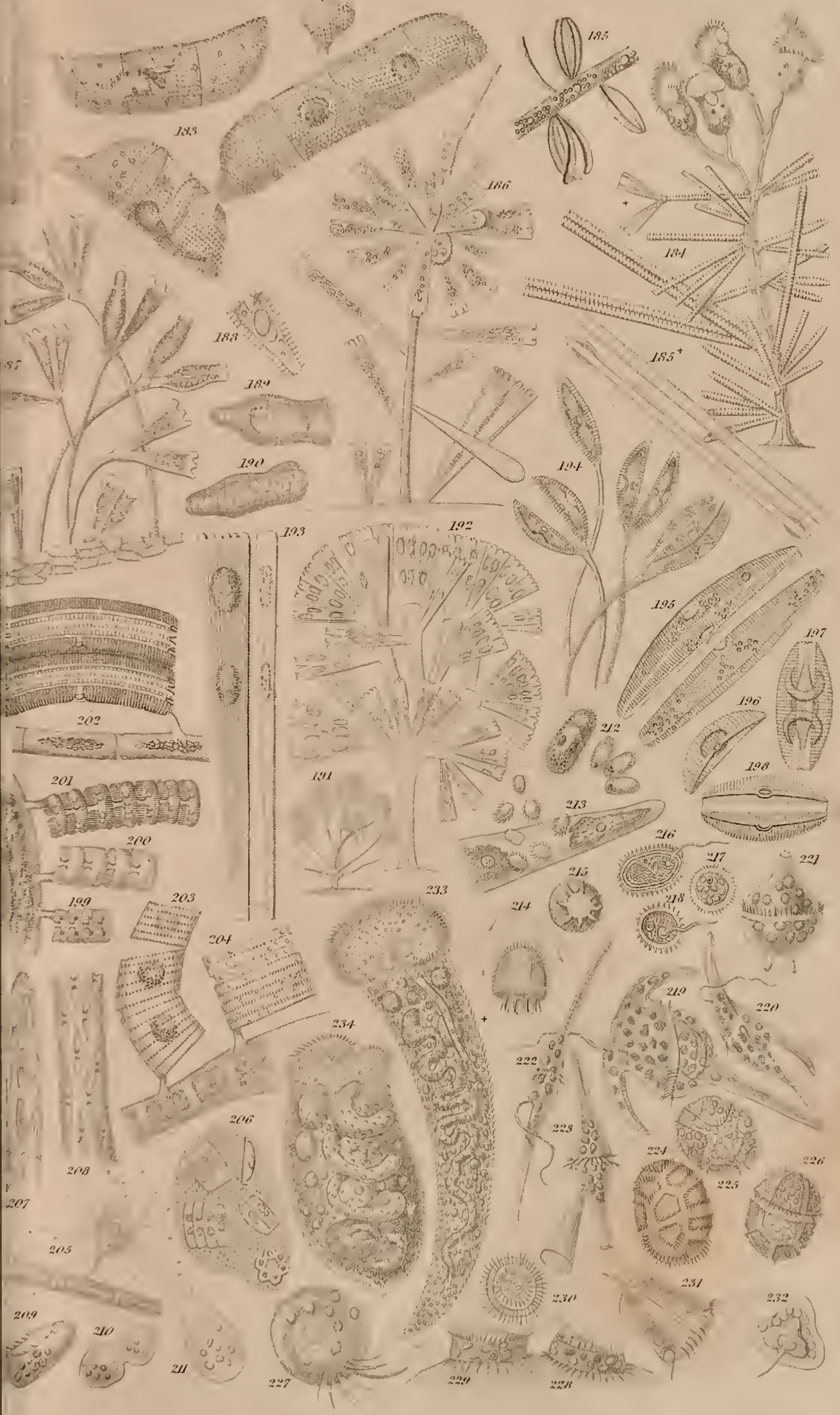

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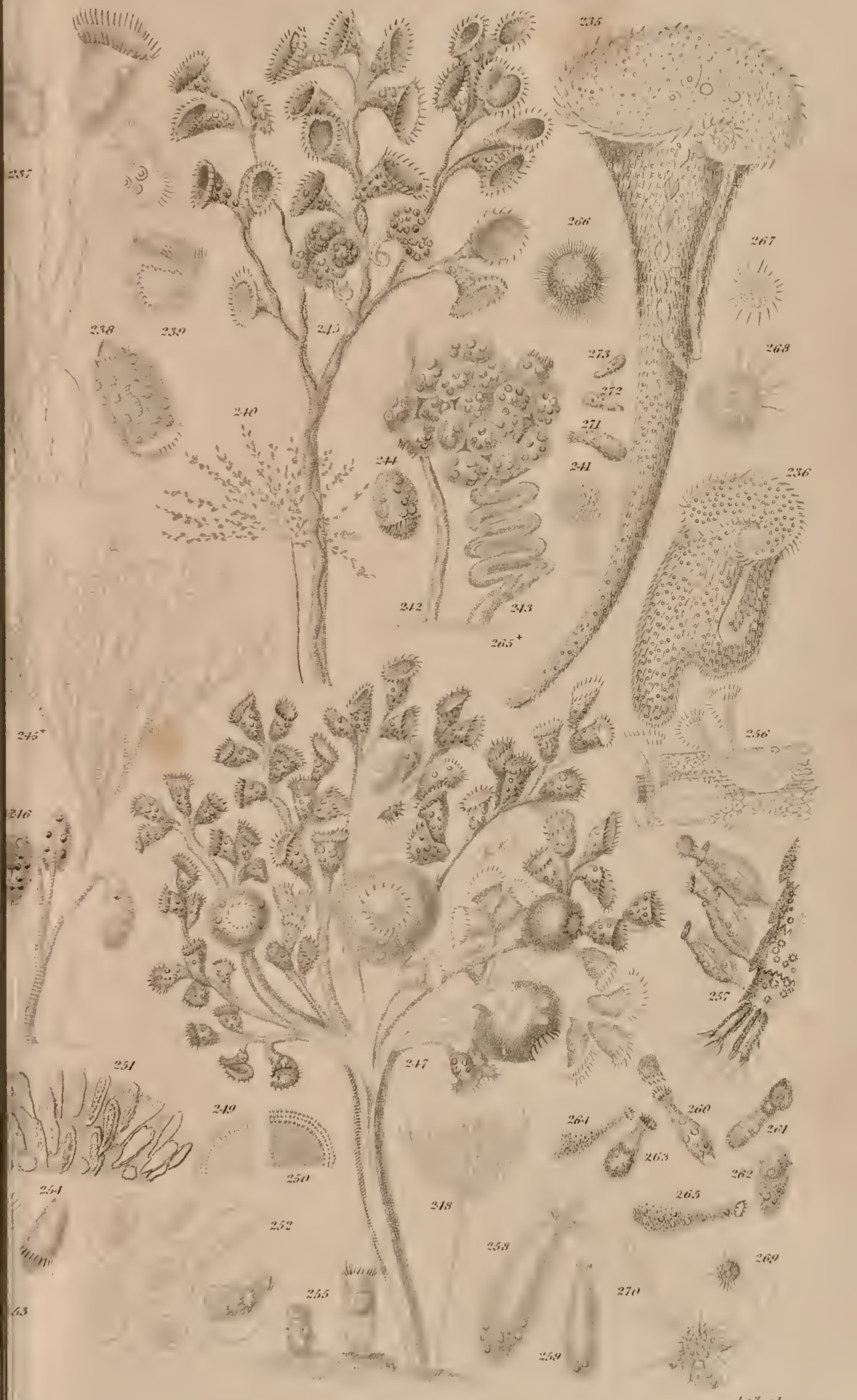

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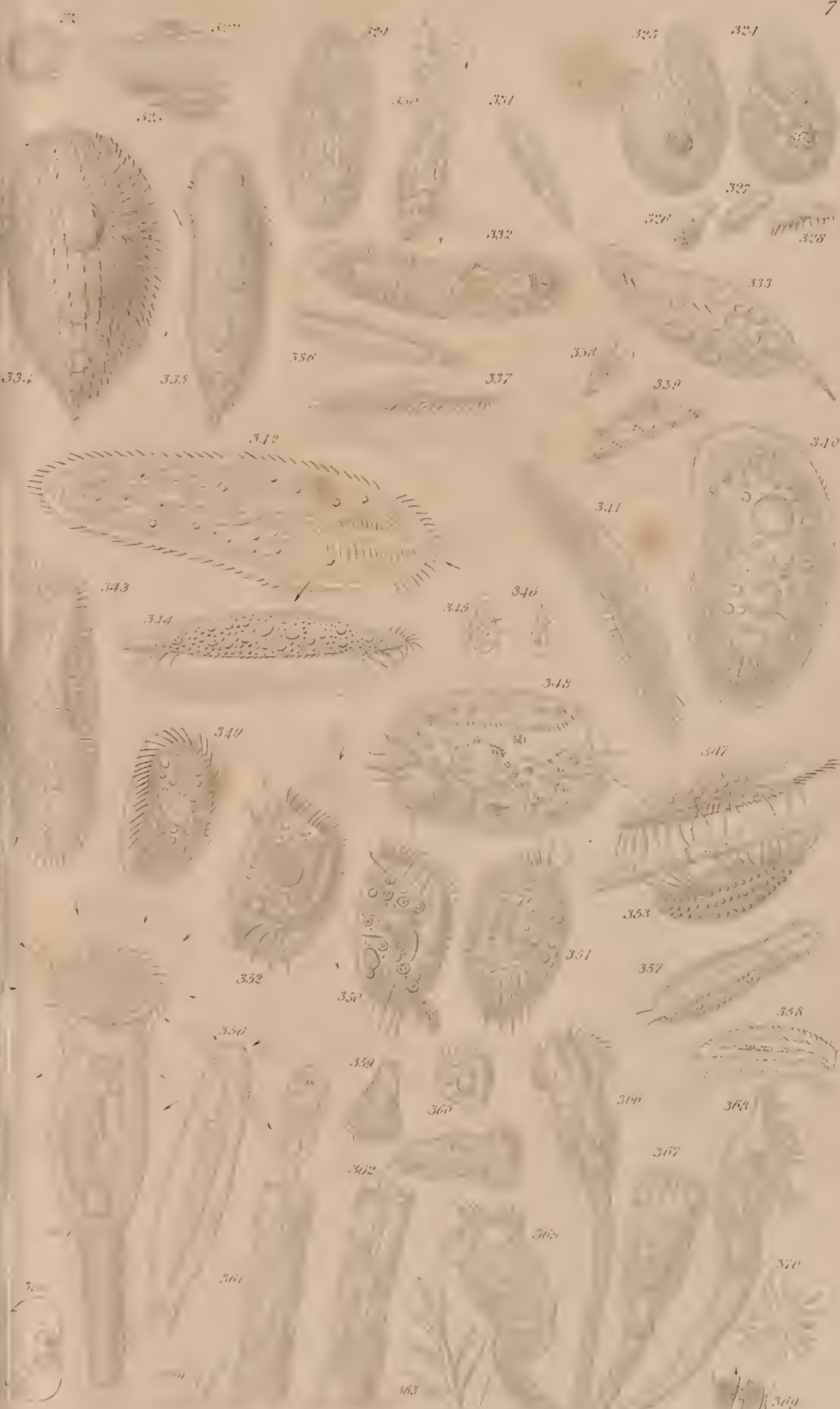

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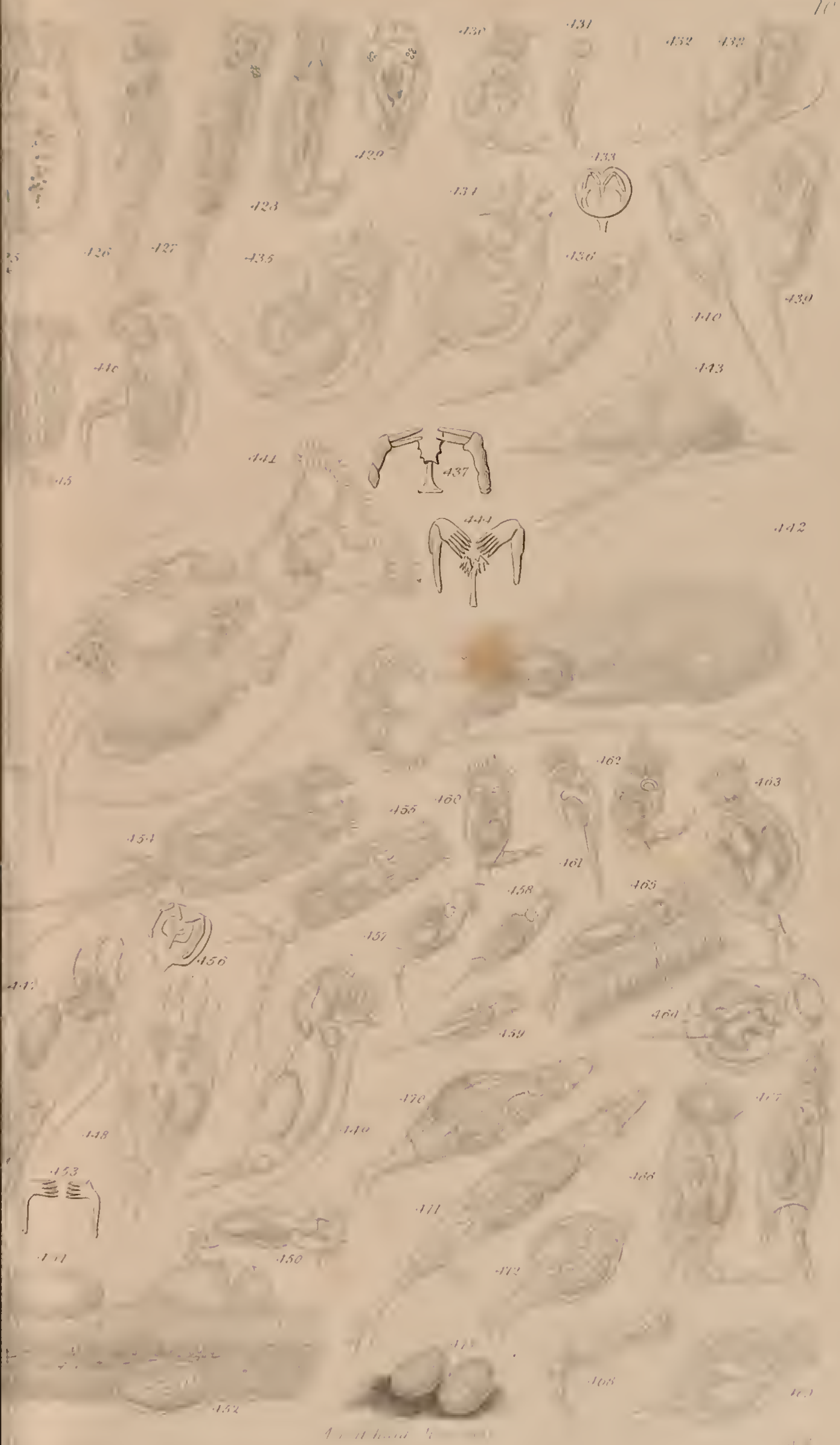

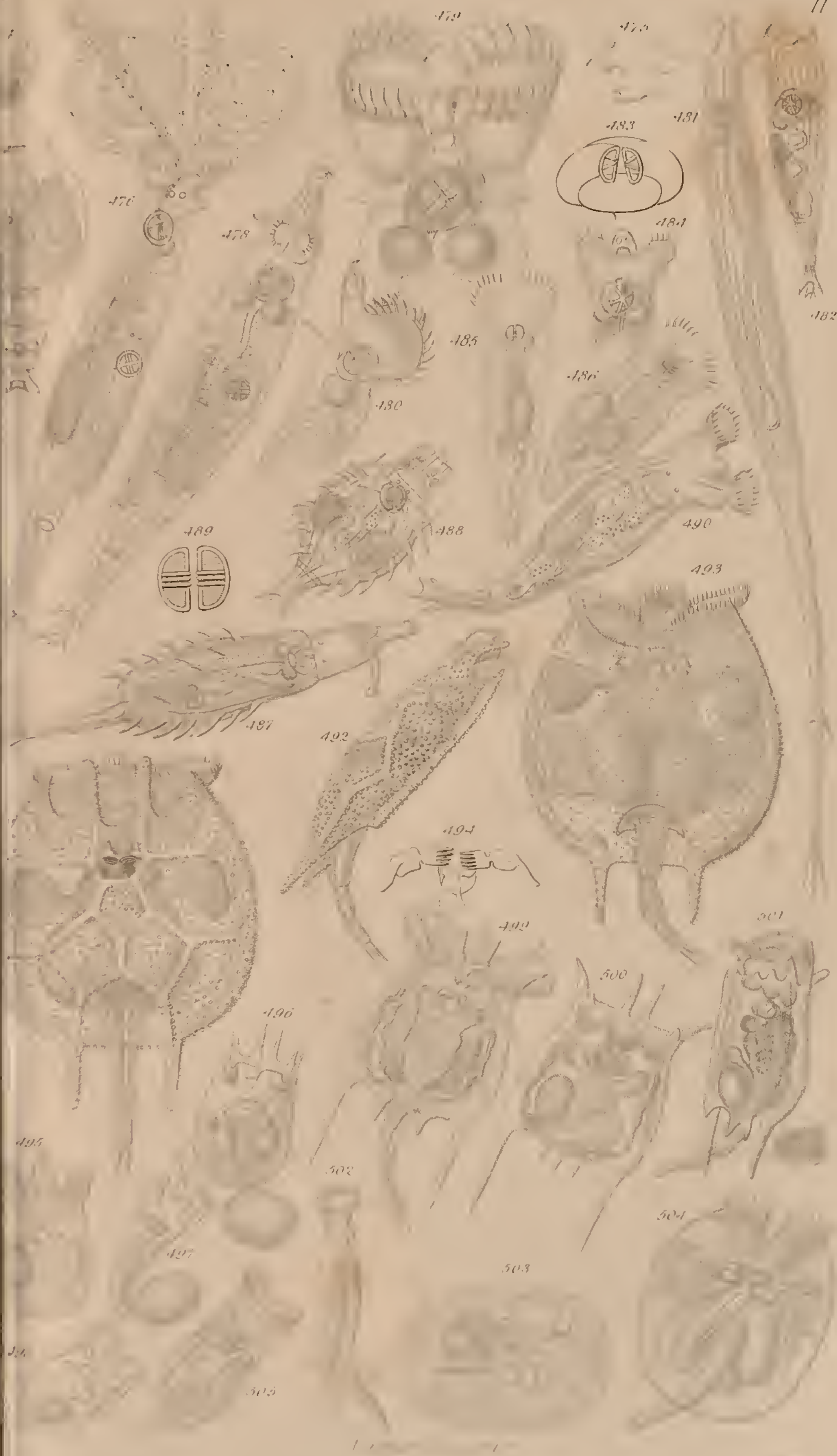
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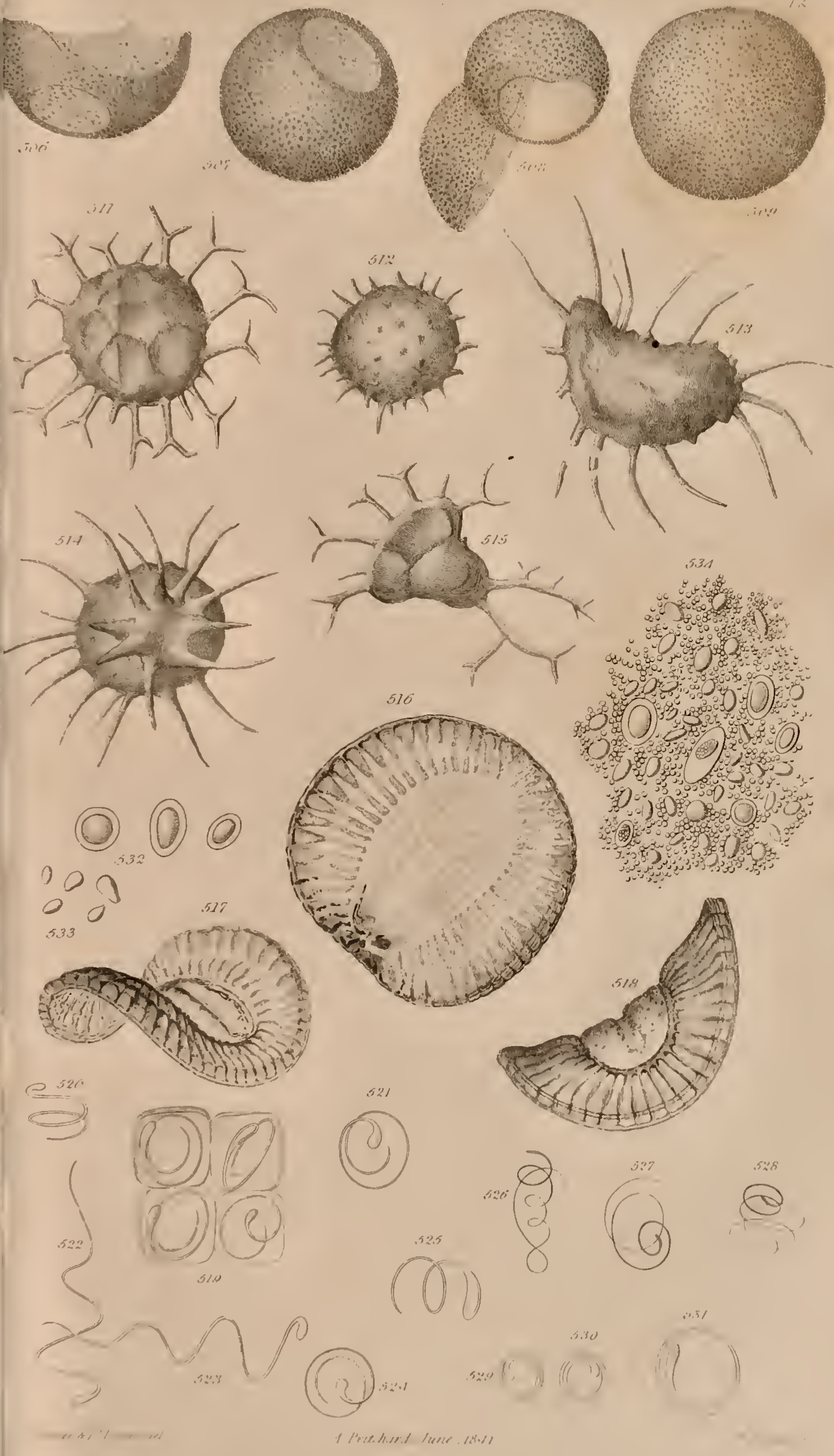

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